## 808TH ORDINARY GENERAL MEETING.

HELD IN COMMITTEE ROOM B, THE CENTRAL HALL, WESTMINSTER, S.W.1, ON MONDAY, MARCH 22ND, 1937, AT 4.30 P.M.

MRS. M. A. EVERSHED, F.R.A.S., IN THE CHAIR.

The Minutes of the previous meeting were read, confirmed and signed.

The CHAIRMAN then called on the Rev. T. E. R. Phillips, M.A., F.R.A.S., to read his paper entitled " Some Recent Views of the Physical Universe and their Reaction on Present-day Thought."

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# *SOME RECENT VIEWS OF THE PHYSICAL UNIVERSE AND THEIR REACTION ON PRESENT-DAY THOUGHT.*

By The REV. T. E. R. PHILLIPS, M.A., F.R.A.S.

IT will be readily admitted that at no period in history has progress in man's effort to understand Nature been more rapid than in our own day. Startling theories have been put forward and discoveries made which have completely revolutionised some of our ideas and given us quite a different conception of the physical universe from that held so recently as the end of the nineteenth century and even the early years of the twentieth century.

Of course, from the times at which historical records begin, there have been those who have desired to understand the phenomena of the external world and to probe into the mysteries of Nature. We have evidences of this in the theories, speculations and discoveries of men of ancient civilisations, like those of Egypt, Babylon and Greece, but for many centuries following the golden age of Greek culture there elapsed a period of almost complete stagnation and paralysis in regard to those matters with which we are now concerned. This arose partly through the fact that men's intellectual activities were turned in other directions, and partly to the overwhelming and paralysing

weight of authority which some of the great teachers of the past—Aristotle especially—exercised over early and mediæval thought. Indeed, many of the beliefs about natural phenomena current until after the coming of the Renaissance seem to have been rooted in mere abstract reasoning and in philosophical ideas as to the fitness of things, rather than in answers to interrogations directly addressed to Nature herself. And so long as men were content to accept without further inquiry the doctrines they had inherited, and to sit down meekly under authority in the belief that the truths and facts of Nature were already sufficiently well known, of course, there could be no such thing as progress in knowledge, and no emancipation of men's minds from the thraldom of superstition under which the peoples of mediæval Europe lived and suffered.

All honour, then, to men like Roger Bacon, Giordano Bruno, Galileo, and others who, in the face of strong prejudice and even, in some cases, of bitter opposition and persecution, daring to doubt and question, laid the foundations of experimental science, or fought bravely in the cause of liberty of thought.

But to-day I wish to speak more particularly of that knowledge of the physical Universe which we owe to Astronomy, and then to refer shortly to some of the ways in which it is reacting on present-day thought. And here let me explain my use of the word *Astronomy*. It is a name which can no longer be limited to the study of the positions of the heavenly bodies, the theory of their mutual relations, the laws which describe their movements, and the information concerning their appearance and physical state acquired by telescopic and photographic observation. Astronomy has taken into partnership with itself the science of Physics, and the union between the two is so close that it is quite impossible nowadays to draw a dividing line between them. Each has helped the other, and it is from their combination that there has emerged that radically changed view of the Universe with which we are becoming familiar. It must, of course, be conceded that there is a large part of modern astronomical theory which is as yet more or less speculative, but all the same, observations and discoveries have been made which render quite untenable many of the beliefs of our fathers, and which have given us not merely an astonishingly extended horizon but a fundamentally different conception of what the external world really is.

We cannot, obviously, consider to-day the development of Astronomy in detail, and must be content with a brief survey of its history.

In the third century before Christ, Aristarchus of Samos had taught that the earth is a planet rotating about an axis and revolving round the sun, but his theory seems to have been very generally overlooked or ignored, and was, perhaps, not taken seriously.* Indeed, for something like eighteen centuries and more—until after the time of Copernicus—the belief which held the field was the primitive and natural one that all other objects—sun, moon, planets and stars—move round the earth in their respective paths, and have indeed been made for the benefit of its inhabitants, and especially its crown and glory—man. It was the function of the heavenly bodies "to give light upon the earth." But after the revival of learning this geocentric theory, though backed by all the weight of philosophical and ecclesiastical authority, could not withstand the increasing strength of developing science resting, as it did, on the surer foundation of observation and mathematics. The Ptolemaic system simply collapsed under the strain of its elaborate and wholly unnecessary system of epicycles; Kepler, making use of observations by Tycho Brahe, destroyed such remnants of the old theory as were rooted in the concept of "the fitness of things" by showing that the motion of the planets is neither uniform nor circular; and then Newton, with his law of universal gravitation, made the Heliocentric Theory an established and consistent whole. Thus was the centre of the Planetary system finally transferred from the earth to the sun.

The next fundamental step is associated particularly with the name of William Herschel, who is rightly styled "the father of sidereal astronomy." In 1811, when approaching the close of his wonderful career as an observer, he wrote:—"A knowledge of the construction of the heavens has always been the ultimate object of my observations," and we read that in the course of his work he made counts of the stars in a very large number of telescopic fields of 15′ diameter as samples for the study of this problem. These showed him that stars of all kinds and

* It was, however, accepted by Seleneus, who lived about a century later than Aristarchus.

magnitudes are concentrated towards the Galaxy or Milky Way, which indicates, accordingly, the fundamental plane of the sidereal system, and that the latter in its general form is roughly disk-shaped or lens-shaped, being several times more extended in the direction of its plane than in the direction of its poles. But in this system our sun is not only *not the reigning monarch*—it is but a comparatively insignificant unit among many thousands of millions of other suns (for every star is a sun) more or less resembling it. Herschel, however, thought it to be near to the centre of the system though slightly displaced northwards from its fundamental plane. Recent research has put it about two-thirds of the way out from the centre towards the periphery, the direction of the hub of the system being indicated by the rich star-clouds in the Sagittarius region of the sky. One reason for supposing the sun to be so far from the centre is that those remarkable objects, the globular clusters, consisting of many thousands of stars massed together, which envelop the Galaxy are, as seen by us, practically all in one hemisphere of the sky.

But besides his study of the Galaxy, Herschel devoted much attention to the large number of faintly luminous objects—the Nebulæ. Many of these, like the famous object in Orion, are obviously associated with our own sidereal system; but there are others which appear to be in quite a different category and to be much more remote. Following the speculations of Thomas Wright and Kant, he called them "Island Universes," believing them to be systems of stars isolated from but subordinate to the major system of the Galaxy. This idea of isolated stellar systems was not generally accepted by the astronomers of the latter part of the nineteenth century and earlier years of the present century, but as the result of recent study—especially by Hubble and others at Mount Wilson—it is now not only restored to favour but firmly established, with the added recognition that, instead of being *subordinate* to our Galaxy, these objects are, at any rate, *comparable* with it, and fellow members with it in a vast Universe of stellar systems—already developed or in the making—whose number is believed to run into many thousands of millions!

As regards dimensions, the diameter of the Galaxy measured across its plane is now believed to be about 100,000 light years, which means that it would take a ray of light, of which the

velocity exceeds 186,000 miles a second, that time to traverse it! The number of suns it contains must be several thousands of millions, in addition to a great quantity of diffused matter. Perhaps the majority of the other systems are considerably smaller than this. Estimates of the mean mass derived by different methods give discordant results, but it must be noted that the general tendency of recent research appears to lead to the conclusion that some of them are much larger than they were formerly believed to be. For example, the Andromeda nebula has been found from photoelectric measures of the region of the sky surrounding it, as well as from the detection of about 140 neighbouring objects which are apparently globular clusters like those associated with our own stellar system, to be far more extensive than was once thought.

The extra-Galactic nebulæ differ considerably in form. What we know of their structure is due almost entirely to the development of photography in conjunction with giant reflecting telescopes; and it would seem that when arranged in sequence they indicate various stages in a majestic process of evolution. Some of them appear as mere roundish or globular masses of hazy light; some, which are elongated or spindle-shaped, are almost certainly flattened, lens-shaped disks seen obliquely; some show a sharp edge such as would be assumed by a mass of gas rotating with increasing speed; in some a dark band, evidently due to absorbing matter, crosses the nebulous object along its major axis; while among those which are best defined and nearest, many are seen to possess a beautiful spiral structure usually consisting of two arms issuing from opposite sides of a central nucleus and coiling round it. On photographs of nebulæ like those in *Andromeda* and the *Triangle*, not only is a granular structure shown in the outer parts of the spiral arms, suggesting groups and clusters of stars, but individual points of light—some of them of changing brightness, like the Cepheid variables and novæ of our own system—are clearly caught.

Is our Galaxy, too, a spiral nebula? From our position within it and almost in its plane it is impossible for us to answer this question definitely, but it seems very probable that it is. We know, at any rate, from the work of J. H. Oort and others that it is rotating, as has been shown to be the case with other systems. And it is interesting to know that the manner of its rotation is similar to that of our planetary system; the inner

parts moving more rapidly than the outer and thereby indicating a concentration of mass near its centre. At the distance of our sun from the hub, the time required for a complete revolution is more than 200,000,000 years!

Something must now be said as to the manner of determining the great distances with which modern astronomy is concerned and the degree of credence that may be allowed them. Of course, the ordinary direct trigonometrical method, for which the diameter of the earth's orbit (186,000,000 miles) is the longest available base line, will not take us really very far (speaking cosmically) into space. It serves for stars not much more remote, say, than 60 light years' distance; but for the majority of the stars other and indirect methods must be sought and applied. Of these I have only time to refer quite shortly to two or three. One of them depends on the study of certain absorption lines in stellar spectra, and makes possible the determination of the *actual* brightness or luminosity of a star, whatever its distance from us may be. And then, knowing from photometric observations what its *apparent* brightness is, and knowing that the intensity of light falls off in accordance with the inverse-square law, we can by a comparison of the *actual* and *apparent* brightness obtain the information desired. This method can, of course, only be applied to stars which give us sufficient light to make the study of their spectra with our present available instruments possible.

Another method which takes us much farther than this in our exploration of the Universe is based on the observation of a certain type of variable stars known as *Cepheids*, after the typical star of their class δ *Cephei*. These stars flash out with greatly increased brightness at regular intervals, like the revolving lantern of a lighthouse, in periods ranging from roughly half a day to several days. And the important thing about them is that a relationship has been established between their periods and their actual brightness, those which show the longest intervals between their outbursts being brighter than those which go through their changes more rapidly. The difficulty has been to establish the numerical scale of the relationship; but it will be clear that this being known, if we assume that the relationship holds good in all parts of space, then we can infer from their periods the *real* brightness of these stars, whether they are situated in the Galactic clouds or anywhere else; then, from a comparison

of their real brightness with their photometric magnitude (*i.e.*, their brightness as seen by us), their distances, and therefore the distances of the parts of space in which they are found. It is by this method that the distances of many of the remote globular clusters and some of the great spiral nebulæ have been determined. As regards these latter, we may add that observations of the brightness of *novæ*, or so-called " new stars," similar to those which from time to time blaze out in our own Galaxy, as well as of certain types of giant stars, on the assumption that they, too, are of about the same brightness as those in our system, have also been utilised, and have led to accordant conclusions. The distances of the remoter objects can only be derived by less certain but probably on the whole fairly trustworthy methods.

And now as to some of the actual results which have been derived. It seems that the nearest of the extra-Galactic nebulæ—such as those in *Andromeda* and the *Triangle*—are at distances of nearly a million ($10^6$) light years—others are enormously more remote than this, the figures for those which are just within reach of the 100-inch reflector at Mount Wilson being of the order of 200 million light years! On the completion of the 200-inch reflector now being built, it will be possible to reach objects at double this distance!

What an amazing difference between the Universe as we now conceive it to be and the Universe of the early astronomers centred on our little world!

But over and above the broad facts of its structure and dimensions as at present known, there are other matters to which we must now give some attention. The Universe is not static; it is a Universe of *motion* and of *change*.

Now in the study of celestial motions, astronomers until comparatively recent times were handicapped in one important respect. Provided that a star is reasonably near and is travelling rapidly, its motion *across* the line of sight can be found from a comparison of its positions on photographic plates taken after an interval of a number of years. But how is its motion *in* the line of sight, *i.e.*, directly towards or away from us—its *radial* motion as we call it—to be determined?

Consider the case of sound—say a definite musical note. We know that if the source emitting it is approaching us (or, alternatively, if we are moving towards it) the compressional waves in the air are more crowded together—or we encounter

more of them in a given time—with the result that the frequency with which the ear-drum is struck is greater than if the distance were unaltered, and the pitch of the note is raised. If, on the other hand, the source is receding from us, we have the opposite effect and the pitch of the note is lowered. So it is with light. If a star or nebula is approaching or receding the frequency of its radiations is increased or diminished, its spectral lines are accordingly shifted proportionally towards the violet or red end of the spectrum and the measured amount of the shift gives the relative velocity of the motion.

We here come to an astonishing fact deduced from a study of the spectra of the extra-Galactic nebulæ we have been considering. It is found that in general their spectral lines show a large *redward* shift, and, if we make allowance for the rotation of the Galaxy, it seems that practically all of them are stampeding away from us as if our particular stellar system were the plague-spot of the Universe! And not only so but the velocity of their retreat is on the whole proportional to their distance, those farthest off receding the most rapidly. The greatest velocities at present known actually exceed 20,000 miles per second! But this general recessional movement of the extra-Galactic nebulæ seems so strange and leads to such astonishing conclusions that doubts have been expressed as to whether the redward shift of their spectral lines is rightly interpreted, and may not be due to some cause other than motion. Such possible causes are familiar to scientists, but, after careful consideration of the various aspects of the problem, it is concluded by most of those competent to judge that the velocity interpretation is the correct one. And so the Universe is apparently expanding at a prodigious rate, doubling, according to Sir Arthur Eddington, its radius in about 1,300 or 1,400 million years!

Support for this view of the Universe is found in the development of the Relativity Theory. According to Einstein, not only has space the property of curvature in the gravitational fields associated with massive bodies, but the sum total of matter in the Universe causes a general closing up of space, so that it has a finite radius. On this theory, space is necessarily *limited* though it is *unbounded*. There is no place in the Universe at which we are compelled to halt—we can always go on like an insect crawling over the surface of a sphere. Of course, we cannot form any really satisfactory mental picture of curved space,

for although we are familiar with the curved surface of a sphere the curvature of Relativity applies to 3-dimensional space, and this is beyond our present powers of visualisation. This is, however, no justifiable ground for denying its existence. Now it has been demonstrated that a Universe such as Einstein at first described is unstable, and the Abbé Lemaitre and others have shown by mathematical reasoning that it must expand. Perhaps the best illustration of what is taking place is the inflating of an elastic bladder or balloon, only we must understand that the expanding space is represented not by the interior but by the *surface* with its gradually increasing radius of curvature. If now we attach to the surface of our balloon a number of small pieces of paper to represent the separate spiral nebulæ and other galaxies, we note that in the course of the expansion they move apart, and that from any one of them the others are receding at rates proportional to their distance. On this view the recession of the nebulæ which we deduce from the redward shifts of their spectral lines is not the expression of any antipathy to our particular system— it would be equally noticeable at any other point in space from which we might choose to make observations ! We may add here that in its present state the Universe is well on its way from the condition of static density in Einstein's picture of it to that of practical emptiness which characterises the Universe described some years ago by the late Dr. de Sitter.

There is an alternative theory which, in fairness, I must not omit to mention, viz., that of Professor E. A. Milne. He abandons the idea of the general curvature of space but accepts the recessional interpretation of the redward shifts in the spectra of the nebulæ. His postulate is that the galaxies, endowed in the beginning with their respective speeds, were originally close together, and that their present distribution, showing velocities proportional to their distance, is the natural result of their scattering. Difficulties about this theory are that it demands very improbable initial conditions, and indicates a very much shorter time scale than seems to be required by the evidence of other astronomical facts. This last difficulty, however, also applies, though less acutely, to the expanding-space theory.

But the Universe is not only characterised by motion ; it is also a Universe of continuous physical change. In the last century we had the development of evolutionary theories both in regard to the larger fields of cosmogony and the more restricted fields of

vegetable and animal life, and although our views on matters of detail may be in some respects far less assured than those of the great scientists of that period, the general principle that the Universe has come to its present state by slow but continuous processes rather than by separate creative fiats or by sudden catastrophic happenings, however violent, may be regarded as established. That catastrohpic events (as they appear to us in our ignorance) occur and play their part in Nature is, of course, evident. In the heavens *novæ*, or exploding suns, are far more frequent than till recently they were thought to be. Indeed, from their observed frequency, taken in conjunction with the probable cosmical time-scale, it would seem that such an outburst may take place at least once in the life of every star! And according to Sir James Jeans the solar system owes its existence to the chance approach of another star to our sun; but despite happenings of this sort it is clearly those processes which, though slow and seemingly feeble, are ceaseless in their operation through immeasurable ages, which are the most effective agents in transforming the face of Nature. I have already mentioned that the extra-galactic nebulæ show a variety of forms and physical states, and that when arranged in sequence they give evidence of a process of orderly development. Yet this development is "at a price," and that price is the gradual dissipation and loss of potential energy. Indeed, as soon as gravitational attraction in the primordial clouds of cosmic particles caused the generation of heat a movement began which has continued and must continue till the end. And, as with the birth and formation of galaxies, so with individual suns a running-down process as well as a building-up process has been and is in evidence. Think of the giant red stars like Antares and Betelgeux, commonly regarded as recently born, and consisting of enormous spheres of incredible tenuity, how much of their present sum total of energy they must lose in becoming denser and whiter and hotter! Or consider our sun already far past, as it seems, the zenith of its glory and now a yellow star on "the down grade"* how does it maintain its still amazing expenditure in radiant energy? Only—as it were—by living on itself! Huge generating machines the stars undoubtedly are, but they are using up their

* It is by no means certain, however, that the sequence of spectral types and colours in the well-known *Russell diagram* of giants and dwarfs actually represents the evolutionary history of individual stars.

capital in the performance of their functions, and, so far as science appears to indicate, the energy they radiate is lost in the vast expanse of space and cannot be gathered up again! If, then, from the point of view of the Universe as a whole, energy is conserved, yet a steadily increasing proportion of it is becoming unavailable for any useful purpose. In accordance with the second law of thermodynamics, "entropy always increases."

It would appear, then, that the evolution of suns and worlds—though we may regard it as the purpose of creation—is actually a temporary phase in a general movement towards a state of uniformity and stagnation in which nothing more can happen. Very wonderful and full of beauty is the present ordered and differentiated physical Universe which the processes of Nature have brought to pass, yet behind it all has been and is going on that ceaseless dissipation of energy which, unless there be some unknown process whereby it will be gathered up again, can only end in what we may call cosmic "death." It would seem that, like ourselves, the physical Universe has its day and then must die!

I must now refer to the two theories—we may properly call them discoveries—which more than anything else have effected a veritable revolution in our ideas concerning the Universe.

One of them is the *Theory of Relativity*, to which some reference has already been made in connection with the theory of the Expanding Universe. Of course, to attempt here any real account of Relativity would be out of the question, and the following short statement must suffice:—In former days physicists assumed, as naturally and as reasonably as in pre-Copernican times men took for granted that the earth is central in the Universe, that measurements of such things as length, duration and mass relate to quantities that are *absolute*, and would be judged to be the same by all observers, and under all conditions of observation. It was only in consequence of certain inexplicable discrepancies between experiment and classical ideas, like that encountered in the famous Michelson-Morley experiment, designed to show the earth's motion through the ether, that the need for the revision of current assumptions became apparent. We now know that measurements made with rods and clocks and scales are not absolute at all, but vary with the motion of the observer relatively to the velocity of light—the latter being unit velocity—or the limiting velocity for moving particles,

and one of the fundamental constants of Nature. The reason why this relativity of dimensions had not been detected was that terrestrial speeds in general are quite negligible in comparison with this velocity.

But there are two things which it is important to note concerning the Theory of Relativity. To begin with, it depends on the fact that our familiar three-dimensional space and time —as Minkowski showed—are merged together in such a way as to form a four-dimensional continuum. To this continuum the name space-time has been given, and it is only in this continuum of space and time in combination that *absolute* length-dimensions (called " intervals " in the language of Relativity), on which all observers, irrespective of their motion, would agree, exist.

The second point to be noted is that the geometry of this four-dimensional continuum is not strictly Euclidean.* It will, of course, be admitted that, apart from the fact that the geometry of Euclid accords in general with our common experiences and has behind it the authority of tradition, there is no reason why we should have assumed that it is the geometry of the physical Universe. We know now that it is not so, and it is to this difference of geometry that such otherwise inexplicable phenomena as the null result in the Michelson-Morley experiment are to be ascribed. At first Einstein applied the principle of Relativity to bodies in uniform rectilinear motion, and this application of it is now called the *Restricted Theory*. Subsequently he extended his investigations to accelerated motion in a gravitational field. Could he find a form of non-Euclidean geometry which would provide a natural explanation of the curved track of a planet in its revolution round the sun? His research was successful, and in 1915 he published his *General Theory*. And so whereas Newton, assuming the geometry of Nature to be Euclidean, had been compelled to postulate an attracting force pulling the planet out of its straight Euclidean path, Einstein was able to dispense altogether with a pulling force and show that in a Riemannian and non-Euclidean space-time with the right degree of curvature the path followed by a planet is that in which it moves quite naturally—apart from any outside interference. Gravitation is thus seen to be a static property of the space-time continuum in the neighbourhood of massive bodies or particles.

* It is commonly called *hyperbolic* geometry.

But nothing has been more astonishing and revolutionary than the discoveries concerning the nature of matter, the character of radiation, and all that is included in the *Quantum Theory* of Atomic Physics. In one of his books, Sir Arthur Eddington describes himself as sitting down on two chairs at his two tables to write with two pens—everything being in duplicate. One set of articles—chair, table, pen—was that of the common every-day experience of the ordinary human being; the duplicate set the same articles as they are in the mind of the twentieth-century physicist; for the hard, solid, material particles of Democritus and Dalton have now dissolved into systems of little more than electric charges. We cannot, of course, go into details of these things, but I must refer to the familiar picture of the atom as given to us some years ago by Niels Bohr, who extended the ideas of J. J. Thomson and of Rutherford. It represents it as consisting of a number (beginning with 1 in the case of hydrogen and increasing with the atomic numbers of the elements) of negatively charged electrons in rapid revolution round a positively charged nucleus —a little replica, in short, of our sun and planet system.* Only we have to conceive of the "planets" (electrons) as restricted to orbits determined by certain conditions and representing certain energy states. They may, however, jump from one orbit to another—from one of lower to one of higher energy state on receiving or *absorbing* an impulse from outside; from one of higher to one of lower energy state when giving up or *radiating* energy into space. But they can only absorb or radiate amounts which, when expressed in ergs and multiplied by the period of the oscillation in seconds, are exactly equal to a quantity known as Planck's *Quantum of Action*.† The result of this is that radiant energy, though in some respects possessing the nature of waves, as is established by the phenomena of diffraction, also has the character of particles, or "photons," thus carrying us back in thought to Newton's Corpuscular Theory of Light. The problem is how to reconcile the two pictures; and although it may be said that light travels

* There is a class of stars known as *White Dwarfs* of which the density may be such that a cubic inch of thin material would weigh tons! This density is attributed to the stripping off of the electrons from the atomic nuclei so that the component particles are packed into much smaller volumes of space than is possible under ordinary conditions.

† This is always the same whatever the absorbing or radiating atom may be. It is $6{\cdot}55 \times 10^{-27}$ erg-seconds.

through empty space like waves, but behaves like bullets on encountering material substances, there is nevertheless a host of problems and difficulties, and inconsistencies with classical theories, which can only be removed by a new and different method of treatment. Accordingly, despite the remarkable degree of success achieved by Bohr's model, it is now for many purposes superseded by the purely mathematical and unpicturable theory of *Wave Mechanics*, as developed in the more recent researches of Heisenberg, de Broghe, Schrödinger, Dirac and others.

I now turn from our modern views of the External Universe to a short consideration of their reaction on contemporary thought.

And first we note that one result of recent research has been to make scientists themselves less dogmatic in their assertions than some of their predecessors were. So much has been discovered that has rendered seemingly impregnable theories either no longer tenable or uncertain, that, despite all the daring shown in their speculations, there is a general reluctance on the part of investigators to claim finality for their findings. An open mind which seeks and sifts all available evidence, and inquires into the smallest discrepancies between observation and accepted theory—a mind which will not allow itself to be fettered or hampered by scientific dogma or preconceived ideas—is characteristic of the present-day scientist.

Another result of our modern outlook is the *overthrow of the old-time materialism*. Relativity has completely undermined our former belief in the absoluteness of the familiar standards of measurement; it has taken away from us the all-pervading ether, or at least reduced it to a mere metrical abstraction, while Atomic Physics has shown us that matter itself is nothing more than systems of protons and electrons, which in their turn may be regarded as only distortions or warpings in the space-time continuum of a relativistic Universe! But if we accept this picture of Nature as true, as seemingly we must, however much it may need to be corrected in its details, what room is there any longer for *materialism* in the old sense of the word?

Another old-time physical concept which is in some doubt to-day is that Nature is essentially *mechanistic* and *deterministic*. It has been the habit of scientists in the past to represent the Universe as like a great machine in which individual parts have no freedom, but can only move and work in a predetermined

way; and it has been the recognised function of science to discover its laws and to describe its motions. But certain observed facts encountered in the study of radio-activity and the apparent discrepancies and uncertainties met with in the realm of atomic physics have made it difficult to fit the behaviour of Nature, considered in her more intimate and secret manifestations, into a scheme of strict causality. Accordingly, it has been suggested that the "laws of Nature," as we call them, are only *statistical laws*, or laws of average behaviour—true of particles in masses or crowds, but not really applicable to individual atoms or particles. Some of our leading mathematical physicists, like Eddington and Jeans, have taken this view, but, on the other hand, there are those, like Planck and Einstein, who are of the contrary opinion and believe that present difficulties and uncertainties will be cleared up by further research, and strict determinism be reinstated. Under these circumstances, it would seem to be well for the ordinary reader of scientific literature to be content to await events, and meanwhile to avoid basing arguments in support of freedom on conclusions which may perhaps be disproved later.

There is an interesting development in recent philosophy which it seems appropriate to mention here alongside the problem of determinism. It is called Holism—a name due to General J. C. Smuts—and is based on the concept that the whole is something more than the mere sum of its parts. A great deal has been written by thinkers like A. N. Whitehead, Smuts and others about the place of *organism* in Nature, and, although it is fully recognised that mechanism must play the major part in the development of any organic structure, as throughout Nature generally, it is nevertheless claimed that the relations and functioning of the several parts are in a sense controlled and directed by the meaning or purpose which is inherent in the organism itself—whatever it may be.

Perhaps the most striking result of modern discoveries is seen in the revival of idealistic and semi-idealistic views. The overthrow of the old materialism by the establishing of the doctrine of Relativity and the mysteries of Atomic Physics, and the seeming breakdown of classical mechanics at the heart of Nature, have combined to increase our appreciation of the significance of mind in our experiences of the external world, and to drive men back on some of the philosophical conceptions of the eighteenth century, of which Bishop Berkeley's idealism is an

outstanding example. Thus Sir James Jeans has written:—"The stream of knowledge is heading towards a non-mechanical reality: the Universe begins to look more like a great thought than like a great machine." Perhaps most of us find our convictions best expressed by Bishop Barnes when he says:—"I conceive that our minds do not create the world inasmuch as it has its being in God: it would be what it is were there no finite centres of consciousness, such as ourselves, in the Universe. But we contribute something—how much we do not know—to the making of the world as it appears in the concepts which constitute our public knowledge. Thus the world *as we know it* has not an independent existence."

The redness of a flower, the blueness of the sky, the sweetness in the blending of musical tones—such things we have long recognised as being in the mind of the percipient as his interpretation of what in physical Nature is mere movement or vibration; but we have now learnt that even such things as the properties of "material" substances, like the qualities of solidity, hardness and continuity in Sir Arthur Eddington's first-mentioned chair, table and pen, are essentially *subjective*. In short, the world *as we perceive* it is largely what we ourselves make it to be; we then project our creations on to Nature and think we find them there! Thus God in reality makes the *perceptual* world through us. Or, as Sir Arthur Eddington, in writing of the selective influence of mind in the relation between the world of physics and that of our everyday experience, has put it:—"Not once in the dim past, but continuously by conscious mind is the miracle of the Creation wrought."

At this point we pass naturally to consider the effect of the new Knowledge on Religion. Now if it be asserted that the validity of belief in God cannot be regarded as demonstrable from the conclusions of science—and it will be generally agreed that it finds its sanctions elsewhere—yet the trend of modern research has been on the whole to remove obstacles to faith and to render belief in the existence of One Supreme Mind in which all that is has its being completely *rational*. We may even go so far as to say that it would be *irrational* to assert that the Universe, which the picture we have been considering shows to be one vast organised whole, could have come into existence and have attained its present ordered state as the result of "a fortuitous concourse of atoms." But the *nature* of the Supreme

Mind—or God—is, of course, another matter, and we find a wide variety of current beliefs on this point.

It would be outside the scope of this paper to discuss the respective arguments for the doctrine of a Transcendent Creator and the various forms of pantheistic belief; but we may note that some current systems have assumed forms which are apparently rooted in the evolutionary ideas of the last century, and are known as theories of *creative* or *emergent evolution*. In these the underlying idea is that in the evolutionary process certain phenomena, such as life and mind, which could not have been foreseen as expected results of physical or mechanical processes, have " emerged," and even God—according to some philosophies—has likewise " emerged " and is developing with the Universe. The theory of an emergent God, however, does not, as Dr. Inge—the late Dean of St. Paul's—has pointed out, fit in well with the emphasis laid to-day on increasing entropy and the running down of the Universe! As he has said :—"A god under sentence of death is no god at all." And we may add that such a Being could not properly be regarded as the " First Cause " or provide any explanation of the existence of the Universe. Only a *transcendent* god in whom the Universe—though evolving in time and perhaps dying with time—eternally exists would seem to satisfy the demands of human thought.

But as to the problem *Deism* versus *Theism*—belief, *e.g.*, in a God like Aristotle's " Unmoved Mover " of the Universe, *or* a God who is, at least in some degree, knowable by us, and has taken the initiative in establishing a measure of fellowship between mankind and Himself—the modern scientific picture of the physical Universe can have no direct bearing. That picture may, however, seem at first sight to present an obstacle to belief in such a divine revelation as *Christianity* claims to have been made to man. We have been thinking of the millions upon millions of suns in our own and other galaxies, and even if Jeans is right in his view that life must be relatively very rare, yet who shall dare to say that in the whole vast Universe there are not multitudes of other worlds where both life and intelligence exist? In any case, it may be asked :—is it reasonable to believe that the inhabitants of this little earth, revolving round a comparatively insignificant sun in one of many millions of galaxies, have been selected for such a unique manifestation of the Divine favour as is generally understood to be claimed in

Christian Theology? Of course, no one can say that such a claim is untrue, but we have learnt a good deal about the probability of error in the case of a restricted geocentric outlook. As in science, so in religion, we must be prepared to take broad views and to re-interpret our beliefs in the light of whatever new knowledge is disclosed to us. But if we hold that God, though transcendent, is *immanent* in the Universe, and if we believe that He reveals Himself in some fashion *wherever* there are minds with the capacity for knowing Him, then the Christian belief in the inspiration of writers and teachers in all ages, and even in a Divine incarnation in human nature, will no longer appear as an improbable concept originating in man's geocentric and self-centred outlook, but as a *rational* creed. It is, at any rate, in complete accord with what our own nobler instincts lead us to postulate in a transcendent degree in the character of the Supreme Mind in whom both the physical Universe and the realm of moral values here and everywhere have their origin and their being.

### Discussion.

Introducing the lecturer, the Chairman (Mrs. M. A. Evershed, F.R.A.S.) said: The last time that I had the pleasure of attending one of your meetings, just three years ago, Mrs. Maunder told us about the very ancient beginnings of astronomy: to-day, Mr. Phillips has promised to tell us about its latest discoveries.

His subject is a large one—the Universe! And the Universe has grown so much larger than it used to be; and the stuff it is made of—just the same "ordinary matter" which makes our Earth—has become far more wonderful and more mysterious.

Mr. Phillips can tell us about these discoveries, because he is himself an astronomer—his work in his own observatory at Headley is well known—and he has opportunities of meeting the men who are working in all the many branches of astronomy and astrophysics. Besides this, he is rector of the parish of Headley, and naturally is deeply interested in the effect on people's minds of these strange new ideas. It is a great privilege to listen to him to-day, and I am very happy to introduce him to you.

Mr. Percy O. Ruoff said: In the course of this able and extremely interesting paper, the lecturer asks whether it is reasonable

to believe that the inhabitants of " this little earth " have been selected for a unique manifestation of the Divine favour. Those who accept the Christian revelation know that " God so loved the world." But whether God has given any other revelation to another world, man has no knowledge and therefore it is idle to speculate.

The statement is made on page 192 that " the general principle that the Universe has come to its present state by slow but continuous processes rather than by separate creative fiats or by sudden catastrophic happenings, however violent, may be regarded as established."

I desire to ask this question: Does the lecturer believe that there was a creative fiat at any time ?

Lieut.-Col. MOLONY said: The first of the Thirty-nine Articles of the Church of England says, " God " is " of infinite power, wisdom and goodness." The discoveries of our astronomers have helped us to realise what that word " infinite " means. Our lecturer, on his last page, has attended to the difficulty which many feel in believing that the great Creator of all things can care what happens to the denizens of this little earth, which must appear but as a speck of dust in His sight.

But there is a reason for the large size of the solar system. When God decided to give Free Will to men He had to take precautions that that great experiment should not end in disaster. If the solar system had been much smaller than it is, men, in their perversity, might have found means to interfere with its smooth running.

It has been often pointed out that the discoveries made by our microscopes have partly balanced those made by our telescopes. The smallest gnat that flies is of wonderful and complicated structure. Men and women are very big compared with these insects, and this consideration should partly restore our self-respect.

But there is a still more important matter to consider. Love has nothing to do with size. Hence it is conceivable that God seeks our love, and for all these reasons we should hold on to our Christian faith, and refuse to be overwhelmed by the vast size of the universe.

Lieut.-Col. T. C. SKINNER said: I am glad to be able to add my tribute of thanks to the author for his beautiful paper. Having

been in correspondence with him for a year past in reference to it, I can judge better, perhaps, than most what it has cost Mr. Phillips in his busy life to give us this paper, and he has indeed put us under great obligation. One would like to touch on many of the interesting points raised, but time fails and I must limit myself to one.

The author refers on page 191 to " evolutionary theories both in regard to the larger fields of cosmogony and the more restricted fields of vegetable and animal life," and here it seems to me he makes a very wise discrimination. Cosmic evolution, as I understand it, implies, after initial creation of some sort, an ordered development in accordance with the laws established by the Creator himself, to be succeeded, perhaps, by decay when the purpose is served. With such evolution I imagine few of us will disagree.

Organic evolution, on the other hand, postulates development of life in unbroken continuity from the lowest forms to the highest, including man, and makes man to be but an improved animal in the upward scale of development. Were the idea scientifically proven, reason would that we accept it at whatever cost; but such is far from the case. Instead, therefore, it must be weighed in the balance and, if found wanting, rejected; and I submit to you that one of the greatest services the Victoria Institute has rendered to science in the past seventy-two years of its existence has been the weighing up process it has established and the strong check thereby exercised on unproven hypotheses which, by reason of premature and insistent publicity, have already done much harm to immature minds.

Hence the advantage that this society offers to devout scientists and philosophers of differing views to meet and discuss their differences in friendly debate, and often compose them in the peaceful atmosphere of sweet reasonableness. To this end the paper we have heard read to-day is an eminent contribution.

Mrs. MAUNDER said: There are two points in the paper by Mr. Phillips that I should like to emphasize. The first is the paralysis in astronomy from just after the golden age of Greek culture until the time of Copernicus. This was, I believe, partly due to the attitude of the philosophers of whom Socrates is the arch type; and, as an example, I will quote one of his dicta: " We neither hear

nor see anything with accuracy. If, however, these bodily senses are neither accurate nor clear . . . must it not then be by reasoning if at all, that any of the things that really are become known to it ? And surely the soul then reasons best when none of these things disturb, neither hearing, nor sight . . . but it retires as much as possible within itself . . . and . . . it arrives at the discovery of that which is."

This is, indeed, the unforgivable sin in science, the denial of the necessity of observation and of making the facts fit the hypothesis, *not* the hypothesis fit the facts.

The paralysis from the first century of our era was also partly due to that mortal disease of astronomy—astrology which became prevalent throughout the then civilised world through the teachings of one Teuchros (or Zeuchros) the Babylonian. As an example of his misdoings : Teuchros devised a system of figures analogous to the zodiacal figures round the celestial equator which were called " houses " and their figures were confused with the zodiac. But the stars that lie in the zodiacal belt (the Ecliptic) are permanent, but the stars round the equator must change continually since the equator itself shifts in space with the precession of the Equinoxes. This confusion of the zodiacal constellations and the " houses " is a confusion of the Ecliptic and Equator, and that in astronomy is as bad as when " the bowsprit got mixed with the rudder sometimes " is hopelessly bad in navigation.

In my second point that I would emphasize, Mr. Phillips always looks forward in time, but I prefer rather to look backward as time seems not quite so long in that direction. He shows that practically all the extra-galactic nebulæ " are stampeding away from us as if our particular stellar system were the plague spot of the universe : the velocity of their retreat is on the whole proportional to their distance, those furthest off receding the most rapidly . . . 20,000 miles per second ! " and that this same stellar system of ours is rotating and " at the distance of our sun from the hub, the time required for a complete revolution more than 200,000,000 years ! "

I was present at that meeting of the Royal Astronomical Society, when Professor de Sitter reversed the problem of the ever-faster recession of the nebulæ, so that it became their ever-slowing

contraction towards a point of time of two to ten thousand million years ago. Professor de Sitter then turned to Dr. Jeffrys and said: "*You* know the significance of those figures," for these were the limits assigned by Dr. Jeffreys to the epoch of the Solidification of the Earth's Crust—the shorter date being the preferable one. Thus, since the Earth took to itself an outer crust, some 2,000,000,000 years ago, our Galaxy has made ten revolutions. I wish we could have had some stellar observations of, say, 100 million years ago when our solar system had moved to the other point of the compass. It might not have made very much difference to our outlook on the Milky Way itself, but it would certainly have given a very greatly altered aspect to our nearest galactic neighbour, the Andromeda Nebula and its smaller companion.

## Written Communications.

Lieut.-Col. L. Merson Davies wrote: I have read the Rev. Phillips' paper with great interest. It affords an able summary of a very large subject, and I admire the succinctness and clarity with which he covers so much ground. As a description of the present state of astronomical knowledge and connecting theory, it could hardly be bettered; but I would utter a *caveat* where the author seems to go beyond the explanation of these things.

Thus he states (on page 192) that it is now "established" that "the Universe has come to its present state by slow but continuous processes rather than by separate creative fiats or by sudden catastrophic happenings." I would point out that if, as is argued, everything since the beginning has consisted in a continual running down of the cosmic machine, then something ultra-creative must have occurred at that beginning in order to supply what all subsequent ages have failed to exhaust. The author's words also show that this supposedly continuous subsequent process may claim to exclude "sudden catastrophic happenings," although it includes such events as Sir James Jeans' "Tidal Theory" postulates—events which are not only sudden, but far more catastrophic than anything pictured by Cuvier. Thus the opposition between continuity and catastrophism is not an opposition between smooth and uneven running as such, but between a running which excludes and

one which includes Divine Interventions. Continuity, it seems, will even allow of creation in the beginning; but it allows of no subsequent interference with natural processes.

That is the crux. So I would point out that fuller seeming evidence of continuity (*i.e.*, history excluding Divine Interventions) is found in geology than in astronomy. The gaps to be bridged are smaller; and the actual past is seen (to some extent) at first hand in the fossil record. But even in geology, as I have elsewhere shown, continuity is anything but demonstrable; so it is one thing to study a scientific theory appreciating its coherence and plausibility, and quite another thing to regard its corollaries as "established."

As an instance of apparent over-confidence in universal mechanics I may cite the reference (on page 197) to the supposed fact "that mechanism must play the major part in the development of any organic structure"—*Must* it? Why? And where is the evidence that it does? We are so used to the endlessly repeated fact that minute human cells develop into men, and the men grow old and die, that we come to take these still inexplicable facts for granted, and attribute them to "mechanism." No form of words, however, that has ever yet been designed to account for these things on mechanistic lines will stand a moment's examination by a capable critic. If a Peter Pan among us actually refused to grow old and die, he would violate all known precedent but no known mechanics.

Yet we confidently talk of mechanics in this connection. It proves our subjectivity. Let us beware of allowing this subjectivity to shake our faith in Revelation—above all when subjectivity takes the form of belief in "continuity," excluding belief in Divine Interventions. Scripture definitely warns us against opposition taking that form.

Mr. AVARY H. FORBES wrote: One cannot but wonder how a divine can have made himself so familiar with up-to-date physical science as to be able to write such a paper as this, in which he sketches the history of astronomy from Aristotle to Einstein, with the approved terminology of experts—"stellar systems," "globular clusters," "relativity," "novæ," "entropy," "hyperbolical geometry," "four dimensional continuum," "ergs," etc., etc.

Mr. Phillips is very optimistic and speaks of " the overthrow of old time materialism," as the result of modern science. In this I can by no means follow him. Scientists may be " less dogmatic " ; they are bound to be so, since almost every text-book of science is out of date after twenty or thirty years ; and the only abiding tendency has been to drive God out of the Universe, and install man in His place ! Some few scientists are really God-fearing men ; but they are the exception, and are rather timid in showing their colours.

The Old Testament saints, who knew nothing of the revelations of our telescopes, could yet say : " when I consider thy heavens, the work of Thy fingers, the moon and the stars which Thou hast ordained, what is man ? " Our discoveries and revelations have had the opposite effect and the rank and file are only too ready to say " Who or where is God ? We cannot find Him. Man is the greatest being in the Universe, and master of his own destiny."

Mr. Phillips speaks of Relativity as " driving man back on some of the philosophical conceptions of the eighteenth century, of which Berkeley's Idealism is an outstanding example." An example of what, may one ask ? Berkeley's Idealism is no " example " of anything. It is an argument *sui generis*, and an epoch-making one ; and as Professor Bain remarks, " all the ingenuity of a century and a half has failed to find a way out of the contradiction exposed by Berkeley." To master his argument *fully* is almost as difficult as to master that of Relativity.

How widely misunderstood Berkeley still is, even by philosophers, was shown when Dr. McCrady of the University of Mississippi, U.S.A., gave a paper here in 1935 on Berkeley's Idealism. It was read before the " Philosophical Society of Great Britain," yet (except for a few lines sent in by Mr. W. E. Leslie) there was only one speaker besides the Chairman (who happened to be myself). Rev. H. C. Morton, Doctor of Philosophy, claimed to have reduced Berkeley's argument to an *ad absurdum* conclusion, which only shows how completely our esteemed and lamented friend misunderstood the argument.

How many scientists have really assimilated Berkeleyism, I do not know. Probably very few. And those who have, as well as those who have not, simply ignore it, as it tends to belittle their craft by proving that they are dealing with shadows *without any*

*objective existence.* Yet those shadows—that materialism—is responsible for our " new morality," which consists in breaking down the barriers against immorality, seen in nudist bathing and nudist homes, new divorce laws—increasing divorce cases by some 900 per cent., and relegating Sunday to a day of work and amusement. Only the other day the Bishop of London told of 100 children, 50 of whom could not tell what happened on Good Friday! No wonder when the teachers are led by such men as Messrs. G. B. Shaw, Aldous Huxley, C. E. M. Joad, all on the side of the Anti-God Movement. *The Teachers' International* says that " religious faith and the idea of God must be replaced by science and the idea of the machine."

Dr. Gaster wrote recently to our Hon. Secretary, Col. Skinner: " It is sad to see morals declining, faith disappearing, ignorance prevailing . . . the flood of barbarism which threatens to sweep everything into the abyss of ignorance, materialism and brutality." Such testimony could be multiplied a hundredfold.

W. Bell Dawson, M.A., D.Sc., M.Inst.C.E., wrote: May I say that the clear summary of the recent views of the physical Universe, which the Rev. Mr. Phillips gives in his paper, is of extreme interest to me, as at my present age (82) I can well remember the whole fascinating panorama of new discovery regarding the structure of the atom and the nature of the Universe. My own researches, during thirty years, into the tides and currents of Canada, a then unknown field, familiarised me with wave progression, in amplitudes and periods under astronomical dominance.

To understand the Universe, we should surely begin at the beginning when God existed alone, before any material things had come into being. For God is independent of the existence or non-existence of time and space. As the Scriptures put it: " He inhabiteth eternity." We may realise accordingly that " time and space are concomitants of creation," as I wrote more than 50 years ago; because there was no need for time and space to exist before matter. For there can be nothing material in a mathematical point; and some fraction of time is essential to any chemical action. We read in the Psalm of Creation (Psalm civ) that God " stretched out the heavens," to give room not only for material things but for living beings also, as indicated further in Isaiah xl, 22.

On the question of life in other parts of the Universe, we need not limit our view to the present, for much may be in preparation; but in any case we have little basis for any opinion apart from hints that God may give us in His Word. The following may be put forward as what we may perhaps gather: This earth is the first inhabited world, in which the great moral and spiritual problems are being worked out; including the outcome of free will, conduct unrelated to the will of God, sin and redemption. (For it is well to remember that the whole *material* universe as well as creatures under the dominance of instinct, act in perfect accord with the will of God.) The solution of these problems as carried out through Christ in this world will be the great object-lesson, the example and warning, to all future intelligent beings for whom the Universe is now being prepared.

Now that we are accustomed to "hundreds of millions of years," we may better understand what is meant in Scripture by "the ages to come," and "as long as the sun and moon endure;" and thus how those now redeemed will be to the praise and glory of God by Christ Jesus throughout all ages, world without end. For the Lord God may have plans for the future beyond our comprehension, based upon what He is now accomplishing in this world during less than a hundred centuries. These plans may even extend beyond the duration of the earth as it now is; for we are told that the time may come when God will lay aside the heavens as a worn-out garment and change His vesture (Psalm cii, 25–27, quoted in Heb. i, 10–12). Modern research seems now to point towards the same outcome; but it cannot foresee the purpose of God to be that righteousness may dwell in the new earth and the new heavens.

### The Lecturer's Reply.

I am grateful for the very kind expressions of appreciation of my paper.

The part which has called forth most comment and criticism is the statement on page 192 to the effect that the general principle of creation "by slow but continuous processes rather than by separate creative fiats or catastrophic happenings may be regarded as established." Some of the speakers, like Lieut.-Col. Skinner, seem to have no objection to this as regards the larger fields of cosmogony

and inanimate creation generally, but have expressed either doubt or disbelief concerning evolution in the varied manifestions of life, including especially the appearance of man.

I can lay no claim to any special knowledge of biology, and on this point will content myself with saying that in my view there is nothing whatever derogatory either to God or Man in the doctrine that it is from primitive and lowly forms, through æons of effort and conflict and by methods which it is for the biologist and the psychologist to investigate and describe, that God has brought about that nature which we humans possess, and which is endowed with such extended mental and spiritual faculties. Whether such things as *life* and *mind* are to be regarded as natural developments in an upward evolutionary movement, or as things which have " emerged " (in the common philosophical sense of the word), or as brought about by special acts of Divine intervention, man is in any case *God's* creation. Except, then, for the traditionalist, the problem of *how* man came to his present state is immaterial to the validity of religious belief, and one on which we may accept without demur the conclusions of scientists whenever it is felt that such conclusions are justified. But some of those taking part in the discussion have questioned the general principle of continuous development as against separate and disjointed creative fiats. In regard to this it seems sufficient to point to the slow and continuous changes which are, as a matter of observed fact, taking place throughout the universe to-day, and to which—it is believed by many of our leading authorities—there can be no halt till all available energy has been dissipated. Moreover, the observed processes of Nature are found—at any rate, when viewed macroscopically—to be not at haphazard but uniform, and to be in accordance with definite formulæ which we term " Laws of Nature." In short *evolution*, in the sense of ordered and continuous change, is unquestionably a present fact, throughout the universe, and unless there have been violent discontinuities in the past—for which there is no shred of evidence—it is to evolutionary processes that we must look for an explanation of its past history. That events which we call " catastrophic " have occurred, and do occur, we know—such as the supposed approach of our sun and another star billions of years ago, and the exploding suns, or *novæ*, of which we ourselves have seen many examples—but these

things are catastrophic only to us in our ignorance of all the contributory causes. It may be of interest to point out that in the case of the novæ it would seem that we already have a glimmering, and indeed more than a glimmering, of what those causes are.

But if it be granted that the evolutionary principle provides a satisfactory explanation of what is happening in the universe to-day, and has happened throughout past ages, there still remains the problem of its *origin*. Here, of course, we step outside the sphere of physical science, the function of which is to give a rational and intelligible account of the universe *as a going concern* and not to explain how it came into being. Questions of origin and kindred problems belong rather to the domain of philosophy. And here, in answer to Mr. Ruoff, I would say I believe that all that has been, is, or shall be eternally *exists* in the Mind of God. The word "fiat" involves the concept of *time*, and while not denying the validity of the time order as, like that of space, an essential condition of our present powers of perception, I, in agreement with the view expressed by Dr. Bell Dawson, cannot conceive of God as limited or restricted by any such necessity. The statement, then, that in the beginning God created the heaven and the earth by saying "let there be" "and there was"—is an expression in language belonging to our human and temporal experience of what in reality is outside the order of spatio-temporal relations. Nevertheless, regarding the matter from the point of view of the physical Universe with which Science deals, we may—and I think we *must*—look for a start in some creative thought or "fiat" of a transcendent God.

I am in much sympathy with Mr. Forbes in his admiration for Bishop Berkeley's idealistic philosophy, as I think my remarks in the paper fully show. But Mr. Forbes objects to my reference to it as an *example* of anything and describes it as *sui generis*. This may in some respects be perfectly true; nevertheless, it was *one*, if the most striking, of the forms of reaction about that period against the older philosophies in which it had been sought to explain everything in terms of matter and motion. And I must protest against the assertion that scientists ignore Berkeleyism on the ground that "it tends to belittle their craft by proving that they are dealing with shadows without any objective existence." So far as concerns the students of physical science *as such*, philosophy lies outside

the scope of " their craft," which is to investigate and describe the *phenomenal* world, and yet actually the coming again into partnership of science and philosophy—largely through the recent development of physical theories—has been one of the outstanding features of modern thought. This is implied in what is said in the paper about the overthrow of the old materialistic ideas and the marked tendency nowadays to interpret the physical world in terms of mind and mental processes.

Mrs. Maunder's reference to one of the sayings of Socrates, the spirit of which seems to underlie the general intellectual attitude of mediæval Scholasticism, is apposite here. It reminds us of how inevitable it was that science should separate itself from philosophy if there was to be any development of knowledge at all. It is in their re-association that we have the greatest hope for the intellectual development of the human race in the days to come.

I must now turn to some remarks made by Lieut.-Col. Davies, who objects to the statement on page 197 that " mechanism must play the major part in the development of any organic structure." Perhaps we assign somewhat different meanings to the word *mechanism*. In the sentence quoted I used it as including all those physical " forces " and processes such as gravity, cohesion, electrical action, capillary action, chemical reaction, etc., which are concerned in the formation of bodies in general, but the point I specially referred to is the fact that there is something in an organism over and above these things ; there is clear evidence of some purposive control or direction to an end.

With Lieut.-Col. Moloney's remarks concerning mere size and love I am, of course, in complete accord, but it was to meet what I think is the *main* difficulty for many who, finding themselves confronted by a Universe of such immensity, desire some assurance of the reasonableness of their faith that I followed the line I did. Belief is surely easier if we conceive of the Supreme Mind as *normally* revealed—that is *wherever* in the Universe there have been, are, or will be minds capable of accepting such revelation, just as the sunlight is perceived wherever there are eyes to see. In other words, we may think of the Divine love not as limited or shown uniquely to mankind but as universal in its scope and operation.