The Evangelic

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MODERN COSMOGONY

The Universe Around Us. By Sir James Jeans, D.Sc., F.R.S. Cambridge University Press, 1929. 352pp. 12s. 6d.

Eos, or the Wider Aspects of Cosmogony. By the same Author. Kegan Paul & Co., London. 88 pp. 2s. 6d.

In these two books we are given a charmingly interesting account of recent astronomical research by Sir James Jeans, who is one of our most eminent workers in this field. They are books that should be read by every intelligent person who desires to learn the latest message of science based on facts of observation and not mere speculations.

During the last thirty or forty years, very great additions have been made to our solid knowledge of the structure of the physical universe. This extension of our information has been due to advances in optical appliances and in physics generally. The art of constructing very large achromatic lenses for object glasses of telescopes and also concave mirrors of glass or quartz silvered on one surface has made it possible to build gigantic telescopes which have immense space-penetrating or light-gathering power.

One of the largest of the reflecting telescopes is at the Mount Wilson Observatory in California, with a mirror over eight feet in diameter. But another of about double the size, viz., a telescope having a silver-on-quartz mirror over sixteen feet in diameter is under construction. Then there are the very large refracting telescopes at the Lick and the Yerkes Observatories in the United States which have achromatic object glasses respectively thirty-six and forty inches in diameter, and are in the front rank of this class of instrument.

The space-penetrating power of a telescope, other things being equal, is proportional to the diameter of its mirror or object glass. This means the distance at which it can disclose an object of given light-emitting power. The light-gathering power is proportional to the area of the mirror or lens. Thus a mirror sixteen feet in diameter will gather one million times more light than the unassisted human eye can do.

Then the next thing that has vastly assisted the progress of observational astronomy is the association of dry-plate photography with large telescopes.

The human eye does not see more or see greater detail in peering through a telescope by prolonged gazing. On the other hand, the effect on a photographic plate is cumulative. A faint object which makes no sensible impression on a photographic plate after a few minutes' exposure will produce an image full of detail after some hours of exposure. Accordingly, nearly all observational work is now recorded on photographic plates exposed in the focal plane of large telescopes. These instruments are mounted equatorially; that is, attached to an axis parallel to that of the earth's axis of rotation, and the telescope is made to revolve by some motive power so that the image of the celestial object viewed by it remains constantly in the same position in the field of view, and can fall on a photographic plate for hours on end.

Then the third great advance has been due to the association of the spectroscope and photography.

When the light of a star is passed through a prism, it is expanded into a rainbow coloured band crossed by black or bright lines. These lines are due to the substances in the outer layers of the star which absorb or emit light. The position and character of these lines tells us a great deal about the star structure. Also in consequence of what is called Doppler's principle, any motion of the star to, or from, us along the line of sight results in a general shift of these lines towards the violet or the red end of the spectrum. Hence it is possible to tell from this shift the star's radial velocity. Also, it has recently been discovered that from the intensity of certain lines in the spectrum we can tell the temperature and therefore intrinsic brightness, or, as we may call it, the candle-power of the star.

When we look at the star-spangled sky on a clear, dark, moonless night, we notice at once a difference in the brilliancy of the stars. This arises from two causes, either a difference in intrinsic brightness or absolute magnitude, or else from a difference in distance. Hence, to obtain any clear idea of the structure of the universe, we need methods for determining star magnitude and star distance. The older astronomers, such as William Herschel and his contemporaries, had not means for making these measurements. When we travel by train, we notice that the nearer

objects—trees, houses, etc.—are displaced relatively to the more distant as we move along. The same thing happens on a minute scale in the case of the stars. As the earth revolves in its orbit, it swings to and fro over a distance of 186 million miles every six months. This produces a very small change in position in the nearer stars called parallax. The stars are so far off that even in the case of the one nearest to us the parallax is not more than three quarters of a second of an angle. This is about equal to the apparent diameter of a halfpenny placed at a distance of five miles from the eye. Refined means, however, enable us to measure this parallax for a certain number of stars. One of the nearest is the star called *Alpha Centauri*. Its parallax shows it to be at a distance of 25 million million miles from our earth. To realise what this means: suppose we take a small pin's head, $\frac{1}{25}$ inch across, to represent our sun. Then our earth will be denoted by a speck of dust only visible under a good microscope placed at a distance of $4\frac{1}{4}$ inches from the pin's head. The most distant of the solar planets, Neptune, will then be represented by another speck of dust placed at a distance of eleven feet from the pin's head.

But to represent on the same scale the nearest star, we should have to place another, rather larger, pin's head at a distance of twenty miles! Such is the vast scale on which the stellar universe is laid out.

The astronomer needs a suitable unit of length in which to express these distances. He selects the distance which a ray of light travels over in one year, and calls it a *Light Year*. It is equal to 6 million million miles. The distance of *Alpha Centauri* is $4\frac{1}{4}$ light years. The distance of the bright star *Sirius* is 8 light years, and most of the bright-stars we see are at a distance of more than a hundred light years. On a clear night we can see stretching across the sky a band of faint hazy brightness, called the Milky Way. This extends all round the earth, and powerful telescopes resolve it into a cloud of stars. Research has shown that all the stars visible to human eyes or with a telescope of moderate power belong to one great cluster included with the Milky Way stars, which are distributed through space in the form of a double convex lens or magnifying glass that is circular in form, but thicker in the middle than at the edges. This vast group of about 3,000 to perhaps 30,000 million stars is called "our galaxy," because our sun is a member of it. The diameter

of this great disc is 300,000 light years, and its thickness about 4,000 light years.

But this does not by any means exhaust the physical universe. Far outside our galaxy there are other collections of stars, visible as faint patches of light often in spiral form in a large telescope. The general opinion is that these are island universes or other galaxies, either of completed stars or else stars in process of development. There is such a patch in the constellation of *Andromeda*, which is just visible to the naked eye under good conditions, or at least aided by a binocular. Research shows that this galaxy is at a distance of about 900,000 light years. Hence the light by which we see it now left those stars long, long before there was any human life on this our earth at all.

The way in which these vast distances have been plumbed depends on an astronomical discovery of great interest. There is in the northern sky a constellation of stars called *Cepheus*, and one of these stars, called *Delta Cephei*, is a short-period variable, and fluctuates in light, the period being five and one-third days. Other similar stars, called Cepheids, are known, which fluctuate in periods from a few hours to a month. In 1912, Miss Leavitt, of Harvard, U.S.A., found that there is a close connection between the period of fluctuation and the absolute brightness or candle-power of the Cepheids. Now the apparent brightness as we see it of a star is directly as the absolute brightness, and inversely as the square of the distance. But the parallax, and therefore distance, of some Cepheid stars has been measured, so that we have the means of determining the distance of every Cepheid star whose apparent brightness and period of fluctuation can be measured. The importance of this fact is that clusters of far-distant galaxies have such Cepheid variables mixed up with them, and we can therefore determine the distance of these galaxies or island universes.

Sir James Jeans tells us that about two million of these extra galactic nebulæ are visible in the 100-inch Mount Wilson telescope. They are at an average distance apart of two million light years, and at a distance from us of about 140 million light years. The imagination falters in the endeavour to grasp the meaning of these stupendous numbers and of the abyssmal depths of space populated by this vast family of galaxies of stars, in their inconceivable numbers; island universes of innumerable stars, floating in the unbounded sea of space.

In addition to knowledge of their distance, we have now some important facts with regard to the size, mass and constitution of the stars. By an instrument called the Interferometer we are enabled in a few cases to measure their diameter. The bright star *Betelgeuse* in the constellation of *Orion* proves to have a diameter of about 300 million miles, large enough to include not only our sun, but the whole orbit of the earth and nearly up to the orbit of Mars.

But the curious fact emerges from research that the mass or so-called weight of all stars is about the same, and never very much greater or less than that of our sun. Hence it follows that these very big stars called giants are merely masses of very rarified gas in a state of intense incandescence. On the other hand, there are stars called dwarfs which are very dense. A small star called the *Companion of Sirius* is 50,000 times more dense than water. That means a little bit of it the size of a match-box would, on our earth, weigh a ton!

Again, stars differ enormously in their surface temperature, and therefore in apparent colour. There are red, blue, yellow and white stars. The surface temperature of our own sun is about 6,000 degrees Centigrade. But on the other hand, some stars have a surface temperature of 23,000 degrees and some as low as 3,400 degrees C. This last temperature is about that of the electric arc, and is the highest temperature we can produce on earth. But this is only the surface temperature. At the centre of stars it runs up to millions of degrees, and is there hot enough to break up atoms into their constituent protons and electrons.

A question discussed by Sir James Jeans in these volumes is the source of this heat. Our sun sends out from each square inch of its surface enough heat to keep a fifty horse-power engine working continually. Whence comes all this heat? The sun cannot be like a red-hot ball of metal, once heated and then left to cool, or else it would long ago have become a cold and invisible sphere. Various suggestions have been made from time to time as to the source of this radiated energy. At one time it was thought to be due to meteorites bombarding the sun. At another time to be due to a gradual shrinking in size; but all these processes are quite insufficient to supply the heat continually sent out. At last, thanks to Einstein's theory, we have the secret revealed. In the interior of the sun and of stars, Matter is being

destroyed and converted into Radiant-Energy, because Matter and Energy are essentially the same thing. The sun therefore wastes away to supply its light and heat.

It loses 250 million tons of its mass every minute. But no-one need be afraid it will not last out our time. The mass of the sun is so enormous that the radiation for thousands of years will not sensibly affect its size.

If, however, the radiation of light and heat from all the stars is only supplied by a melting away of their matter, and if this process is irreversible, that is to say, if Matter is not reproduced from radiation, then the extremely important deduction may be made, that there must have been some act of Creation of Matter at a time not infinitely remote in the past. The physical universe is like a clock which is running down and which cannot wind itself up.

This conclusion is also supported from a consideration of the spontaneous but irreversible transformation of radio-active matter such as Uranium into non-radio-active matter such as Lead, as well as by the doctrine of the dissipation of Energy. But now, if there must have been in the not very remote past a definite act of creation in the first production of Matter, what becomes of the doctrine of Cosmical Evolution, which asserts the absence of any such discontinuities? If the evolutionary theory fails in one place, it fails altogether.

Creation does not necessarily imply a departure from the law of causation. Nor does it essentially consist, as often assumed, in making something out of nothing instantaneously.

We know nothing as yet about the processes by which Mind can express itself in Matter, but the borderland between the realms of the two realities may not be sharply marked, and may involve stages and processes hidden from us as yet, and perhaps for ever inexplicable to us.

The entirely important fact is that modern cosmology supports, and does not deny, the necessity for Creation by Mind and emphasises the opening statement of the inspired Scriptures, "In the beginning God created the heaven and the earth."

Two very interesting questions are discussed by Sir James Jeans in the concluding chapters of these books, viz. the origin of our solar system of planets and the question of life in other worlds than ours.

Our sun, no doubt, had its origin in a spiral nebula. Various

speculations have been made by Kant, Herschel, La Place and others as to the mode of origin of the solar planets. Sir James Jeans considers they may have been due to the approach of another star to our sun, creating great tidal effects and drawing out from our sun two long streamers of gaseous matter which later on congealed into the planets. He works out the details of the process in a very ingenious way.

A question more interesting to the general reader is whether there are in space any other worlds habitable by such beings as ourselves.

In the first place, none of the stars themselves are possible as habitations. They are all either masses of incandescent gas at terrible temperatures or else such dense and highly gravitative masses that on them we should be crushed by the weight of our own heads.

There may be stars which have planets circulating round them and similar to our earth. We know that many stars exactly resemble our sun in structure, size and temperature. The question then arises whether if the solar planets were due to some very unusual event, such as the near approximation of two stars the same kind of event may not have happened in other cases. No telescope yet built, or possible to build, could show us any planet like our earth circulating round some distant star. Life as we know it is only possible within very narrow limits of temperature and other conditions as to atmosphere. Hence, conditions on our earth for animal and human life *may* be unique. We cannot tell. Neither do we know at present the purpose and sufficient end of this vast plenitude of worlds without end which astronomy reveals to us.

But where knowledge fails, faith may assure,

> That nothing walks with aimless feet,
> That not one life shall be destroyed
> Or cast as rubbish to the void,
> When God hath made the pile complete.

Whilst those whose ears are attuned to the spiritual message may catch some echoes of the celestial anthem,

> "Great and marvellous are Thy works Lord God Almighty, Just and true are all Thy ways Thou King of Saints. . . . for Thou hast created all things and for Thy pleasure they are and were created."

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