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SATURDAY, NOVEMBER 22, 1930.

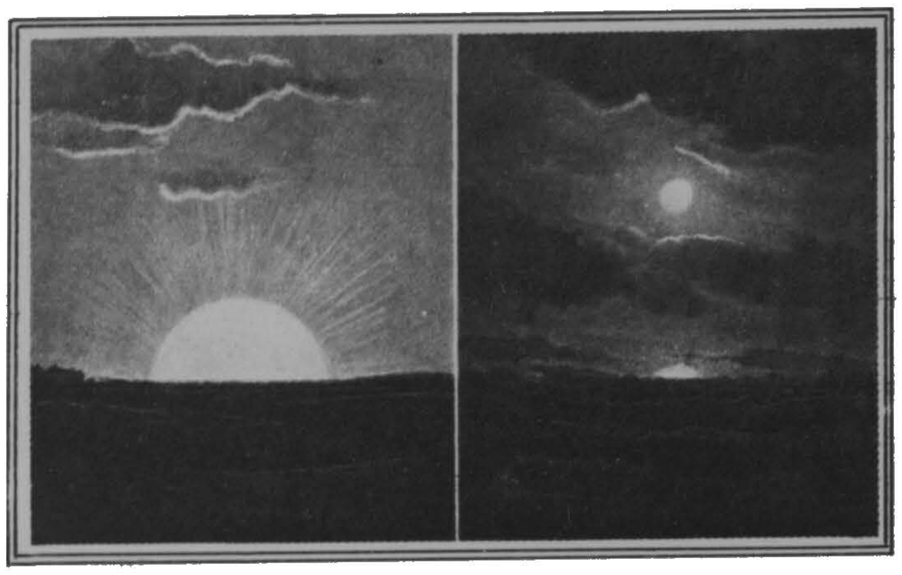
"MYSTICAL MATHEMATICS OF THE CITY OF HEAVEN."

BEING AN APPRECIATION OF

*"THE MYSTERIOUS UNIVERSE." By SIR JAMES JEANS.**

(PUBLISHED BY THE CAMBRIDGE UNIVERSITY PRESS.)

"THE Mysterious Universe" is an expansion of the Rede Lecture delivered by Sir James Jeans before the University of Cambridge in the early part of this month. In the first chapter, "The Dying Sun," the author discusses certain physical characteristics of the Universe, declares what will be its ultimate fate, describes the conditions in which life can subsist in it, and gives us some idea of the position occupied by life in the universal scheme.



A COMPARISON OF THE APPARENT SIZE OF THE SUN AS SEEN FROM THE EARTH (ON LEFT) AND FROM JUPITER (RIGHT), AND OF THE EXTENT TO WHICH (OWING TO DIFFERENT ROTATION SPEEDS OF THE TWO PLANETS) IT APPEARS (AT THE EQUATOR) TO RISE ABOVE THE HORIZON OF EACH IN ONE MINUTE.

"Seen from Jupiter," writes M. Rudaux, "the Sun would appear to hasten across the sky, and at dawn would seem to rush up with a speed astonishing to human eyes. No less surprising would be the fact that, owing to Jupiter's distance from the Sun, the solar disc would appear five times smaller in diameter than it does to us and would give twenty-five times less light."

Life can only exist on a planet, and planetary systems are few, the perquisite of one star in 100,000. They were formed by one star accidentally coming so near another as to raise, by the force of attraction, tidal waves upon its surface; these split off, solidified, and became satellites. When we reflect that if a star were reduced to the size of a ship, and distances in space correspondingly curtailed, each ship would still be a million miles from its nearest neighbour, we need not wonder that planetary systems are of rare occurrence; even when we bear in mind that the total number of stars "is probably something like the total number of grains of sand on all the seashores of the world." The "zones within which life is possible, all added together, constitute less than a thousand million millionth part of the whole of space."

"Into such a universe," says Sir James, "we have stumbled, if not exactly by mistake, at least as the result of what may properly be described as an accident . . . it seems incredible that the universe can have been designed primarily to produce life like our own; had it been so, surely we might have expected to find a better proportion between the magnitude of the mechanism and the amount of the product. At first glance at least, life seems to be an utterly unimportant bye-product; we living things are somehow off the main line." A second glance, however, leads to a modification of this statement.

The conditions favourable to maintaining life must come to an end. The sun, lacking the means to replenish its heat, grows ever colder; and the earth, instead of drawing nearer to the sun, by a law of dynamics withdraws ever further from it. And the universe itself is threatened with a "heat-death": its total energy having been uniformly distributed, all its substance will be reduced to a uniform temperature a temperature far too low to support life.

Sir James Jeans goes on to describe how the formulation of the Quantum Theory has revolutionised the basic principles of physics and freed it from its dependence on the Law of Causation. This law had been accepted ever since Man ceased to attribute "the seemingly erratic and unordered course of the universe to the whims and passions of gods, or of benevolent or malevolent lesser spirits." "The whole course of events had been unalterably determined by the state in which the world found itself at the first instant of its history: Nature could move only along one road to a predestined end."

"Out of this," says Sir James, "resulted a movement to interpret the whole material universe as a machine, a movement which steadily gained force in the latter half of the nineteenth century. It was then that Helmholtz declared that the final aim of all natural science is to resolve itself into mechanics, and Lord Kelvin confessed that he could understand nothing of which he could not make a mechanical model."

Professor Planck's "tentative explanation of certain phenomena of radiation" and the theory arising out of it, "that the course of nature proceeded by tiny jumps and jerks, like the hands of a clock," did not at once sound the death-knell of the time-honoured conception of physics; for nothing is more strictly mechanical in its action than a clock. But in 1917 Einstein showed that this theory entailed "consequences far more revolutionary than mere discontinuity. It appeared to dethrone the law of causation from the position it had heretofore held as guiding the course of the natural world." Science could not now assert that "state A was inevitably succeeded by state B"; it could only say that "state A may be followed by state B or C or D or innumerable other states. It can, it is true, say that B is more likely than C, C than D . . . but, just because it has to speak in terms of probabilities, it cannot predict with certainty which state will follow which; this is a matter which lies on the knees of the gods—whatever gods there be."

Sir James Jeans summarises some of the experiments out of which was established what Professor Heisenberg calls a "principle of indeterminacy." In spite of Sir James's extraordinary gift for making the rough places of science plain to the lay mind, these experiments, and the analogies, drawn from everyday life, that illustrate them, are not always easy to follow. But the conclusion is plain enough. "Our man-made machines are, we know, imperfect and inaccurate, but we have cherished a belief that the innermost workings of the atom would exemplify absolute accuracy and precision. Yet Heisenberg now makes it appear that Nature abhors accuracy and precision above all things."

The next section of the book is occupied with the question of "waves." "We are beginning," says Sir James, "to suspect that we live in a universe of waves, and nothing but waves. . . . These waves are of two kinds; bottled-up waves, which we call matter, and unbottled waves, which we call radiation or light. If annihilation of matter occurs, the process is merely that of unbottling imprisoned wave energy and setting it free to travel through space. These concepts reduce the whole of the universe to a world of light, potential or existent, so the whole story of its creation can be told with perfect accuracy and completeness in the six words: 'God said, Let there be light.'"

THE APPARENT SIZE OF THE MOON AS SEEN WITH THE NAKED EYE (ABOVE) COMPARED WITH THAT OF JUPITER (BELOW) SEEN THROUGH A SMALL TELESCOPE MAGNIFYING FIFTY TIMES.

In an article relating to his drawings on the opposite page and those on this page, M. Lucien Rudaux writes: "Despite its great distance away, the planet Jupiter appears large enough to enable us to observe its chief features even with a very modest telescope."

(*See Colour Illustrations on the Opposite Page.*)

But it is difficult to imagine a wave which does not "travel through something concrete"; it must have a medium to undulate in. This medium is ether: "modern physics is pushing the universe into one or more ethers." A hard saying, and the chapter in which Sir James Jeans expands and illustrates it is one of the most difficult in the book. The new ether, like the old one, is only a hypothesis, a figment of the mind, its existence cannot be proved: we assume it is there because the assumption can be made to account for certain observed physical phenomena. The old conception of "mechanical ether" has been discarded. If it really corresponded to any physical condition in the universe; if, as some thought, it was stationary, or, as others thought, it was blowing round and through us at the speed of a thousand miles a second, it could be used as a standard to determine at what rate the universe was moving. But all experiments to discover the pace at which the universe moves have failed. "In

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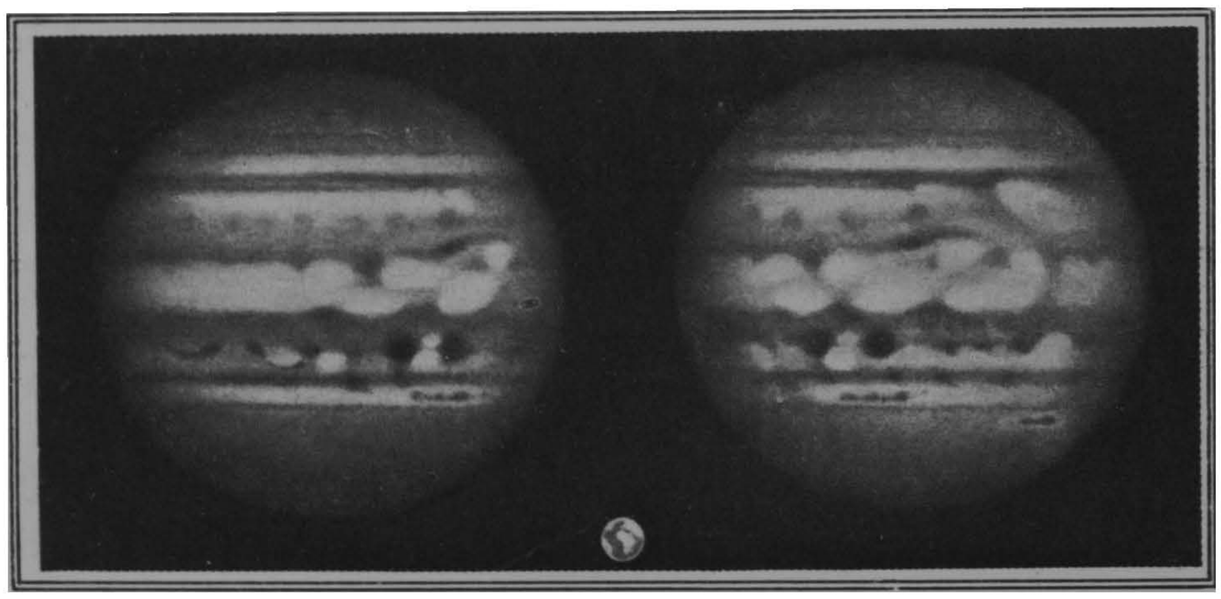

EVIDENCE OF JUPITER'S RAPIDITY OF ROTATION: TWO DRAWINGS OF THE PLANET MADE AT AN INTERVAL OF 1¼ HOURS; AND (BELOW) A SMALL CIRCLE REPRESENTING THE SIZE OF THE EARTH COMPARED WITH JUPITER'S ENORMOUS GLOBE.

"Jupiter's huge globe," writes M. Rudaux, "revolves on its own axis so rapidly that one can easily calculate its alternation of day and night. Its rotation takes 9 hours 55 minutes. The length of its day, from sunrise to sunset, is thus only 4 hours 57 minutes. Jupiter, with its diameter of 141,600 kilometres (88,500 miles), is 1295 times larger than the earth. No oceans and continents appear on its surface. All we can see is dark and light zones more or less parallel with its equator, and varying from time to time in number, size, and coloration. They are believed to represent prodigious gaseous disturbances, with a dense atmosphere concealing Jupiter's globe from us. Does such a globe even exist, possessing a solid surface? It is hardly probable. The colossal planet may be a world in process of formation."

* "The Mysterious Universe." By Sir James Jeans, M.A., D.Sc., Sc.D., LL.D., F.R.S. (Cambridge University Press, 3s. 6d.)

Born (with the Other Planets) of "An Unusual Accident": Jupiter.

FROM THE DRAWINGS BY M. LUCIEN RUDAUX. (COPYRIGHT.)

TWILIGHT ON JUPITER. AN IMAGINARY PICTURE OF AN EVENINC SCENE ON THE VAPOROUS SURFACE OF THE PLANET (PROBABLY A WORLD STILL IN PROCESS OF FORMATION) AT A POINT FROM WHICH SEVERAL OF ITS NINE MOONS (OF WHICH THREE ARE REPRESENTED HERE) WOULD BE VISIBLE AT THE SAME TIME.

JUPITER FROM ITS NEAREST SATELLITE, WHOSE SURFACE IS DEPICTED IN THE FOREGROUND: AN IMAGINARY REPRESENTATION OF THE HUGE BANDED PLANET, WHOSE DISC, FROM THAT VIEW-POINT, WOULD APPEAR OVER 8000 TIMES GREATER IN EXTENT THAN THAT OF OUR MOON (SHOWN AS A WHITE DOT ABOVE FOR COMPARISON) AS SEEN FROM THE EARTH.

In his Rede Lecture on "The Mysterious Universe," delivered recently at Cambridge, Sir James Jeans, the famous astronomer, ascribed the birth of the solar system to a close approach of the sun and another star—a "rare event" which occurred, he said, some 2,000,000,000 years ago. The tidal pull of the second star raised on the sun a prodigious mountain, which at last "was torn to pieces and threw off small fragments of itself." These fragments evolved into the planets. It was an unusual accident for suns to throw off planets.

M. Lucien Rudaux, the French astronomer-artist, describing his drawings, recalls the fact that Jupiter is 1295 times larger than the Earth, and has nine moons. The upper picture shows three of the moons as they might appear, at twilight, from the surface of Jupiter. Of the lower picture M. Rudaux writes: "Let us suppose that we are on Jupiter's nearest satellite. Seen thence, the colossal planet would look like a fantastic moon whose apparent disc was over 8000 times greater in extent than our own full moon."

"THE MYSTERIOUS UNIVERSE."

(*Continued from Page 922.*)

1905 Einstein propounded the supposed new law of nature in the form—'Nature is such that it is impossible to determine absolute motion by any experiment whatever.'" The calculation cannot be made because there is no such thing as "absolute rest." "A ship which is becalmed is at rest only in a relative to the earth; but the earth is in motion relative to the sun, and the ship with it. If the earth were stayed in its course round the sun, the ship would become at rest relative to the sun, but both would still be moving through the surrounding stars. Check the sun's motion through the stars and there still remains the motion of the whole galactic system of stars relative to the remote nebulæ. And these remote nebulæ move towards or away from one another with speeds of hundreds of miles a second or more; by going further into space we not only find no standard of absolute rest, but encounter greater and greater speeds of motion."

So the idea of a mechanical, all-pervading ether has been dethroned, and the principle of Relativity "reigns in its stead." To get even a glimmering of what this principle means needs a great mental and imaginative effort. "The phenomena of electro-magnetism may be thought of as occurring in a continuum of four dimensions—three dimensions of space and one of time—*in which it is impossible to separate the space from the time in any absolute manner.* In other words, the continuum is one in which space and time are so completely welded together, so perfectly merged into one, that the laws of nature make no distinction between them, just as, on the cricket field, length and breadth are so perfectly merged into one that the flying cricket-ball makes no distinction between them, treating the field merely as an area in which length and breadth separately have lost all meaning."

The physical phenomena of the universe are to be explained in terms of this continuum. Matter, gravitational forces, are represented by "crumplings" of the continuum: even electro-magnetic forces may soon be reduced to the same lowly status. "If so, the universe will have resolved itself into an empty four dimensional space, totally devoid of substance, and totally featureless except for the crumplings, some large and some small, some intense and some feeble, in the configuration of the space itself." As a final figure of the universe, Sir James Jeans offers the soap-bubble: "The universe is not the interior of the soap-bubble, but its surface, and we must always remember that, while the surface of the soap-bubble has only two dimensions, the universe-bubble has four—three dimensions of space and one of time. And the substance out of which this bubble is blown, the soap-film, is empty space welded on to empty time."

The closing chapter, in which Sir James shows the bearing of these remote, majestic abstractions on the origin and purpose of human life, has a poetical quality, and a tentative tone, that one does not usually associate with the utterances of scientists. "Many would hold," he says, "that from the broad philosophical standpoint the outstanding achievement of twentieth-century physics is not the theory of relativity . . . or the theory of quanta with its present apparent negation of the forces of causation, or the dissection of the atom with the resultant discovery that things are not what they seem; it is the general recognition that we are not yet in contact with ultimate reality." And another discovery is that the meaning of the universe is most likely to be apprehended by the most abstract of the sciences, pure mathematics. If the universe be susceptible of explanation by mathematicians, then man is not the anomaly, the accident, that he appeared to astronomers and physicists, nor are his processes of thought an irrelevance in the final sum of things.

"If the universe is a universe of thought, then its creation must have been an act of thought. Indeed, the finiteness of time and space almost compel us, of themselves, to picture the creation as an act of thought. . . . Time and space, which form the setting for the thought, must have come into being as a part of this act. . . . The new knowledge compels us to revise our hasty first impressions that we had stumbled into a universe which did not concern itself with life or was actually hostile to life. The old dualism of mind and matter, which was mainly responsible for the supposed hostility, seems likely to disappear . . . through substantial matter resolving itself into a creation and manifestation of mind. We discover that the universe shows evidence of a designing or controlling power that has something in common with our own individual minds—not, so far as we have discovered, emotion, morality, or æsthetic appreciation, but the tendency to think in a way which, for want of a better word, we describe as mathematical." Even those of us who are not naturally mathematicians can take some comfort from this assurance.

L. P. H.

NOTES FOR THE NOVEL-READER.

(*Continued from Page 938.*)

child, virtually an orphan: his father was killed in the war, and his mother put a whole continent, another husband, and a policy of neglect between her and her hopeful son. Adrian was brought up among older people, a grandfather and an aunt, who loved him but were hardly companions for him. What wonder that at school and afterwards he formed, without much judgment, clinging attachments that brought him more pain than pleasure? Mr. Armstrong tells his story with that sympathy, insight, and scrupulous literary style that have made his novels prized by discriminating readers.

In "Unwillingly to School," Anne Allardice, to me a new novelist, has written an amazingly vigorous, humorous, and, at times, appalling account of the life and trials of a mistress in an elementary school. She excels in depicting relationships (*e.g.*, between Jane and her second headmistress, Miss Player) in which there is no love lost. Her love-affair with the clergyman is less convincing. Miss Allardice is one of those writers who describe squalor, poverty, mental and physical wretchedness, with such high spirits, she might be writing of a party or a picnic or other occasion dedicated to joy. She is a caricaturist; but her caricature preserves, in all its rich ugliness, the lines of the original. She is a promising writer.

"A Middle-Class Man" is yet another study of youthful idealism choked and corrupted by material prosperity. Socialist in his youth, and leader of a "revolutionary" band of Socialists, Jürgen becomes bourgeois in his middle age. But the conversion is only partial; a psychological "conflict" is set up, and not resolved without much fantastic (and, it must be admitted, improbable) behaviour on Jürgen's part. There is a great deal that is obscure in this book; it is more German even than most German novels. "Plain Murder," on the other hand, is almost too plain. To describe a man capable of committing two murders and projecting two more, without recourse to morbid psychology as an explanation of his actions, implies a conception of human nature which one would be loath to accept. But Mr. Forester has a powerful imagination which almost compels the reader into an unwilling suspension of disbelief.

Of all these books, the one I enjoyed most was Miss Grace Zaring Stone's "Bitter Tea." It is the story of a New England American girl who went to China to marry a missionary. But before she achieved that aim (if she ever did) the disorder of the times made her the guest—half-prisoner, half-guest—of General Chen. Her experiences under his hospitable roof, curious, enigmatic, never quite melodramatic, are subtly and delightfully told. Megan's position was humiliating, ridiculous, and dangerous; but her courage, her heart, her good manners, and her sense of humour are equal to the strain. The book raises many issues, moral and philosophical. It is an enchanting story.