REVIEWS

Constitution et évolution de l'univers. By A. VERONNET. Paris: Gaston Doin et Cie., 1926. Pp. iv+475. Fr. 20 net.

The problems of cosmogony are of perpetual interest, and in this small volume of 475 pages an astronomer at the University of Strasbourg, A. Veronnet, gives us the picture as he sees it after fifteen years of study upon certain mathematical phases of the subject. The point of view is that of the mathematicians of the nineteenth century, just as was that of Jeans in his *Problems of Cosmogony* about eight years ago. Since the publication of his book, Jeans has advanced to more modern ideas as to the nature of matter and energy, but Veronnet prefers to plod along the old path, and it is a curious picture which he presents to us.

One would suppose that a modern mathematician would feel the need of a few postulates before expounding his views upon the universe in general. Veronnet does not feel this need. His postulates are carefully concealed (perhaps he was not aware of them), and a casual reader is left with the impression that everything is a matter of calculation and therefore quite certain. With a word of caution to the reader that a mathematical discussion, like every other logical discussion, rests upon a variety of assumptions which may or may not be granted, we will proceed to a description of the evolution of the universe as it is seen by our author.

Before the stars were formed all matter existed in the form of atoms and molecules scattered more or less uniformly throughout all space. Each molecule attracted every other molecule, at least those within a certain distance, and the resultant attraction on each molecule was perfectly determined. (The reviewer would remark that these assumptions imply that Newton's law of gravitation is only an approximation; and so fundamental an assumption should be explicitly stated and discussed.) Previous to this, however, "Even matter did not exist. Only the ether, the universal electromagnetic medium, filled space with positive and negative electrons." (Most of us would say that electrons were matter.) The ether and electrons came into existence somehow from some previous state but no conjecture is made as to how, nor why the number of positive and negative electrons are equal in number and equal, though opposite, in charge. The author is content with the remark that nothing is known on the subject. Gravitation is a feeble residue which remains after the electrons have been combined in the form of atoms. (It should therefore vary inversely as the cube, or some higher power, of the distance.)

The primitive nebulosity was not absolutely uniform—it was more like the clouds in a mackerel sky—and no initial motions of the atoms or molecules are assumed. The stars began to condense in the midst of the denser portions of the nebulosities without any sharp boundaries at first; the space between the stars being cleared gradually as time elapsed. The first fragments to condense were the smaller ones of a few tons or thousands of tons like comets and meteors, the stars being condensations of a second order. Naturally, the temperatures to which the stars rise depend upon the initial masses, and thus stars of all types are to be found from the white to the red. (Veronnet fails, however, to explain why there are no stars a million or more times as massive as the sun.) The star clusters of various types are condensations of the third order—fourth, and higher orders are not mentioned.

The process of evolution has proceeded more rapidly in some regions than in others. In our stellar world (the galaxy?) the evolution of the stars, and *a fortiori* of meteorites and atoms, is completed; but the concentration into star clusters has little more than commenced. The condensation of the clusters is in process and eventually, when they have reached mechanical equilibrium, their diameters will be much smaller than they are at present. On the borders of the galaxy the evolution is more advanced, and outside of it still more. Spiral nebulae are formed by the approach of two clusters and their rotation about each other like double stars. The galaxy is merely a region where the evolution of clusters has not yet made much progress.

As for the planets, they were originally fragments of the primitive nebulosity, but, on account of their remoteness from the central condensation that eventually became the sun, they were deflected from a direct descent into the sun by the attraction of neighboring stars. Their orbits, at first very elongated, have been rounded by the resisting medium. Furthermore, the sun possesses more than the single planetary system with which we are familiar; it possesses many planetary systems. The others, formed later, are very remote and have highly elongated orbits like comets. This total mass exceeds that of the sun by at least ten times.

Other stars possess similar planetary systems more or less remote. Occasionally one of the nearer planets falls into a star which then becomes a nova. From the nova the star passes to the giant stage by virtue of an envelope of particles which is maintained about it by radiation pressure. Before the infall of the planet it was an ordinary dwarf star.

The heat of the sun is derived from the sun's gravitational potential in accordance with Helmholtz' theory, but it must not be supposed that the sun's radiation has been uniform. Its mean radiation in the past has been fifteen times its present radiation, so that the age of the sun and its attendant system of planets is only one million or so years. (Jeans assumed in his *Problems of Cosmogony* that for the first two hundred million years the radiation of the sun was one-fortieth of its present radiation, the present rate extending back into the past only five million years.) This need not disturb the geologists, for under this intense radiation water would be boiling, and with boiling water the process of erosion would be a thousand times faster than the present rate. As for the radioactive method of determining the age of the earth, "It seems indeed very uncertain to base a calculation of millions of years upon a few milligrams of helium," and anyway it is only a fragment of rock which was analyzed, and as the earth was formed of meteorites, the rock may have been very old when it fell in.

So much for the past! In the future the sun will continue to cool and the earth also, unless it should happen to fall into the sun. The energy of the sun is radiated away and is lost, so that the universe as we know it now is but a transitory phase. The individual stars cool and become dark. The star clusters will collapse into single stars of great mass and brilliancy which will have very long periods of life. As time elapses the centers of radiation become relatively fewer but more massive. Since the universe is infinite it is not necessary to suppose that the process will ever end, for the sweeping-up process can go on forever. The phase of the life of the universe which we see is merely that phase in which the gravitational potential energy is being transformed into radiant energy. There is no question raised as to the phase of the universe which succeeds the radiant phase. The radiated energy simply disappears from consciousness.

Such is the fantastic picture which is presented by Veronnet. It is offered to us with numerous mathematical formulae as to details, but with no evidence whatever of any meditation upon the larger or philosophical aspects of the subject. Apparently he has accepted the traditional point of view in which he was educated and seeks merely to make it more precise as to details. Whether the universe has emerged from some unknown state and is proceeding through the present conditions to some other equally unknown state, or whether the universe remains always in its present state in the sense that atoms and stars, radiant energy and potential energy, have always existed and always will exist is a postulational matter that cannot be settled by experiment, observation, or mathematical discussion. Consequently, the second law of thermodynamics, however useful it may be as a laboratory rule, cannot be accepted as a philosophical principle on the basis of evidence. If the reviewer's experience in testing people is of any value, most people distinctly dislike the postulate that the universe is proceeding from one unknown to another, and with equal distinctiveness favor the postulate that the universe remains always the same; it is a matter of taste, and *de gustibus non est disputandum.* Nevertheless, there is no point in taking up with the unpopular side with no mention whatever of the existence of the other.

There is no evidence, however, that Veronnet consciously made any choice. He pins his faith to the Helmholtz contraction theory and then makes his philosophy conform to the theory, instead of taking it the other way about by making his theory fit his philosophy.

The idea that the heat of the sun is maintained at the expense of the sun's mass is erroneously ascribed to Perrin (1919) on relativistic grounds. This hypothesis was first advocated by the present reviewer on purely classical grounds in this *Journal* in 1918. It has also been advocated by Nernst (1921) and by Jeans and Eddington (1924). The vast amount of energy which is obtained in this manner is regarded by Veronnet as a fairy-like contribution by the relativists, not to be taken seriously. He is wrong, however, in stating that the gravitational potential energy is the only adequate source of energy that we really know about. The electrostatic potential energy is just as real (in the classical sense) as the gravitational potential energy, and it is vastly greater, the ratio of the electrical forces to the gravitational forces on the electron being 2×10^{39}.

If one admits that the electrons cease to exist when a positive and a negative electron approach as close as the radius of the positive electron, the amount of energy released is almost exactly that given by the theory of relativity. Curiously enough, Veronnet seems willing to admit that atoms have come into existence, but seems unwilling to let them go out of existence. Jeans and Eddington, on the other hand, seem willing to admit that they go out of existence but not willing to admit that they come into existence. In the cosmology of the reviewer the atoms, like all other physical units, come into existence and go out of existence. Their construction makes the skies of night cold and dark; their destruction is the source of the stellar energies. The time scale is not a few million years, as Veronnet would have it, but millions of billions of years. The geologists and biologists will regard an estimate of one million years for the age of the earth as utterly absurd—and still more absurd will it appear to the student of the dynamics of the galaxy.

Veronnet has heard of the planetesimal hypothesis of the origin of the planetary system, for he says with regard to it:

> One sees none of the necessary mechanical conditions fulfilled here. The sun turns much too slowly to give a sufficient moment of momentum to the planets. It could give them only a part of its moment of momentum while with a mass of merely 1/1000 they possess 30 times as much. It is therefore an absolute impossibility.

This opinion shows that the author is wholly ignorant of the planetesimal hypothesis. It is a pity that he mentioned the matter at all. He could be pardoned if he had never heard of it, but having heard of it and having mentioned it he was under obligations to represent it correctly. As a matter of fact, the planetesimal hypothesis cannot be reduced to a set of mathematical equations, but neither can geology, paleobotany, and paleontology. The time is past when all of the secrets of the universe can be read out of a set of mathematical equations, and Veronnet seems to have devoted himself exclusively to this branch of knowledge. We are tempted to paraphrase the quotation, "A little learning is a dangerous thing," and make it read, "The exclusive use of mathematics is a dangerous thing in cosmology."

The book is printed on paper of poor quality, and the proofreading has not been carefully done.

W. D. MacMillan

Statistical Mechanics with Applications to Physics and Chemistry. By Richard C. Tolman. New York: Chemical Catalog Co., 1926. Pp. 334. $7.00.

The book is one of the "Monograph Series" of the American Chemical Society. Its purpose is to give in a single place a systematic presentation of the theory of statistical mechanics, together with a survey of most of its fields of application in physics and chemistry. Professor Tolman's book should be of great importance to the chemist, and the physicist, also, will find much of interest between its covers.

After a very brief treatment of the canonical equations of Hamilton, the statistical ensembles of Gibbs, Boltzmann, Jeans, and Ehrenfest are considered. The Maxwell-Boltzmann distribution law is next derived and applied to problems involving molecular velocities, energy partition, and specific heats. At this point the quantum theory, in the form expounded by the Wilson-Sommerfeld rule of quantization and Bohr's frequency