trophysical Observatory. Professor Frank E. Ross returned to the Yerkes Observatory in April, after six months spent at the Mount Wilson Observatory. Dr. Louis G. Henyey has been awarded a J. S. Guggenheim fellowship for study and research at the University of Copenhagen with Professor Bengt Strömgren. He expects to leave for Europe on September 1. Miss Francis Sherman has been appointed assistant at the Yerkes Observatory in the place of Mr. Edwin Ebbighausen who has accepted a position at Wilson College, Chambersburg, Pennsylvania. On March 18 Professor Albert W. Recht of the University of Denver passed the examination for the degree of Ph.D. On the same date Miss Sherman passed the examination for the degree of M.S.

Dr. Thornton L. Page, who had been teaching astronomy on the campus of the University of Chicago since last October, came to the Yerkes Observatory in March, and Dr. Philip C. Keenan returned to Chicago in order to teach during the spring quarter. This exchange arrangement will make it possible for both men to devote a considerable part of their time to research.

Dr. Chandrasekhar's astrophysical monograph, "Introduction to the Study of Stellar Structure," was published by the University of Chicago Press in January. Professor Russell's monograph on "The Masses of the Stars" is scheduled for publication early in the summer, and arrangements are under way for a monograph by Dr. P. W. Merrill on "The Spectra of Long-Period Variable Stars."

In view of the dedication ceremony of the McDonald Observatory on May 5 and the astronomical symposium which has been arranged in connection with the dedication through the generosity of the Warner & Swasey Company, no special lecturers have been invited to the Yerkes Observatory during the summer. The regular staff will be somewhat depleted by the absence of Professors Kuiper and Chandrasekhar who have been invited to take part in the second international astrophysical conference in Paris during July. However, astronomers who wish to carry on research at the Yerkes Observatory during the summer, or graduate students who wish to register for advanced courses, will find a number of interesting problems and stimulating discussions.

Yerkes Observatory, April 6, 1939.

OTTO STRUVE.

Book Review


This book on stellar structure appears as the second volume in the series of astrophysical monographs sponsored by the Astrophysical Journal. In the introduction the author states that in the monograph an attempt is made to develop the theory of stellar structure from a consistent point of view, and, as far as possible, rigorously.

The subject is limited to the theory of static stellar structure, as problems of stellar instability and stellar rotation have been entirely omitted. Within this scope, however, the author has aimed at completeness.

The book is divided into twelve chapters. Each chapter is followed by a section of biographical notes. The first chapter is devoted to thermodynamics. The presentation given follows Carathéodory. One finds here in a relatively small space
a very clear exposition of the fundamental laws of thermodynamics. The fact that Carathéodory's axiomatic theory is presented for the first time in English enhances the importance of this chapter. Applications of the fundamental laws of thermodynamics of special importance in the theory of stellar structure are considered in the following chapter. The main topics are: thermodynamics of a perfect gas, uniform expansion of gaseous configurations, the virial theorem, and the thermodynamics of black-body radiation. In the third chapter the problem of stellar structure is attacked in a general way. No special assumptions are made except that the stars are in hydrostatic equilibrium. On this basis the order of magnitudes of the most important physical quantities characterizing the stellar interior is derived.

The fourth chapter deals with polytropic and isothermal gas spheres. Its one hundred pages make it the largest chapter in the monograph. In the words of the author, it represents, largely, the work of the great pioneers, Ritter, Lord Kelvin, and Emden. The introductory section on convective and polytropic equilibrium is of considerable interest, giving a rather detailed exposition of the physical reasoning that led, originally, to the consideration of polytropic equilibrium. Most of the space is, of course, devoted to the mathematical theory of the properties of the solutions of the Lane-Emden differential equations. The presentation is remarkably complete, and by unification and simplification the author has succeeded in making it relatively easy to follow. The bibliographical notes appended to this chapter are of special interest, containing a detailed analysis of the contributions of Lane, Ritter, Lord Kelvin, and Emden.

The first four chapters together form what the author aptly calls the "classical," in contrast to the "modern," part of the monograph. The "modern" part starts with a chapter on the formal theory of radiation. Beginning with the fundamental definitions, it leads up to the equation of radiative equilibrium, the equation of transfer in the stellar interior, and the equation of hydrostatic equilibrium. In the following chapter the problems of gaseous stars in hydrostatic equilibrium are attacked. First, general properties of stars in radiative equilibrium are discussed. Then follows an analysis of the stability conditions for radiative equilibrium and a discussion of the problems of convective equilibrium. Eddington's standard model is discussed in detail. The distribution of temperature, density, and pressure, the total energy, and the mass-luminosity relation are derived. More general models are discussed from the point of view of homology transformation. A special effort is made to bring out clearly the generality of the mass-luminosity relation. The chapter which follows deals with the concrete applications of the general results, discussed thus far, to the actual stars. It deals especially with the application of the mass-luminosity relation to the observational material on masses, radii, and luminosities of the stars. The theoretical calculation of the mean molecular weight and the opacity of stellar matter is considered in detail, and the method of determining the relative abundance of hydrogen, helium, and heavy elements from mass, radius, and luminosity described. The Vogt-Russell theorem is proved, and its bearing upon the chemical constitution of the stars discussed. Finally the conclusions concerning chemical constitution drawn from the Vogt-Russell theorem and the results derived from the mass-luminosity relation are correlated.

In chapter eight the theory of stellar envelopes, defined as that outer part of the stars which contains some suitably chosen small fraction of the mass (ten percent, say), is considered. The author has been able to develop the theory of stellar envelopes to a high degree of completion. In order to appreciate the value of a theory of stellar envelopes it must be remembered that the envelope, as defined
above, normally extends as far as half way from the surface to the center. The author makes use of the theory, partly to strengthen the results already obtained for normal stars, and partly to investigate, in an empirical way, the central condensation of very massive stars, for which the ordinary stellar model apparently breaks down. What is presented in this chapter is essentially the theory of a part of the stellar model that is characterized by mathematical simplicity. With a view to applications to the stars mentioned, for which the ordinary model is unsatisfactory, the theory will no doubt be extended so as to embrace the whole of that part of the star, about which our present physical information is reliable. In the following chapter some further stellar models are considered. The results obtained in previous chapters are partly confirmed and partly extended. One notes especially a discussion of the point-source model with constant opacity. This may be regarded as a first step toward the extension of the envelope theory mentioned above.

Chapter ten is devoted to quantum statistics. The discussion leads up to the complete equation of state of the electron gas, in particular that of the degenerate electron gas. The author expresses his regret that, owing to lack of space, it has proved impossible to make this chapter entirely self-contained. In fact, the fundamental Boltzmann relation connecting statistical mechanics and thermodynamics has to be taken for granted. Otherwise, however, the presentation is complete and clear. The next chapter deals with degenerate stellar configurations and the theory of white dwarfs. It contains sections on the gaseous fringe of a white dwarf, completely degenerate configurations, the discussion of the observational material and the theoretical mass-radius relation, the stellar criterion for degeneracy, the effect of radiation pressure, composite configurations, and partially degenerate configurations. In an appendix one finds extensive tables of white-dwarf functions, not previously published.

The last chapter is concerned with the problem of the origin of stellar energy. The author emphasizes that this chapter is on an entirely different level from the preceding ones, the subject being as yet in an early stage of development. An attempt is made to indicate some general trends in the current approach to the problem. This chapter should be quite useful as an introduction to a field that is, at the present moment, that one among the many fields of the theory of stellar structure which is in the center of interest.

As a whole, the monograph represents the outcome of an admirable effort, through which every argument in its five hundred pages, and every one of its more than two thousand equations has been brought to its proper place in a carefully planned design. In consequence, the monograph is not only a very valuable handbook for the astrophysicist, but should also prove extremely useful to the student of the subject. In fact, the developments, though sometimes naturally difficult always start right from the beginning with fundamental principles, and the full details are given.

The astrophysicist who works in the field of the theory of stellar structure has to accept the handicap that he cannot at every step of his developments compare theory and observation. On the other hand, he has the great advantage of dealing with objects which are, from a theorist's point of view, in many respects ideal. Therefore, while some of the results presented in the monograph may have to be modified in the course of future work, it appears that most of the content will be of permanent value.

The book has been very nicely produced, the printing, especially of the equations, is very satisfactory.

Bengt Strömgren.

Copenhagen, Denmark, March 18, 1939.
POPULAR ASTRONOMY

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