And really I am a little disappointed in Dr. Darnell. After all my efforts to point out the undesirability of using mongrel words, he asks whether "supercritical" or "hypercritical" is correct, and seems to imply a preference for the Latin-Greek hybrid rather than for the nice, pure Greek compound.

GEORGE W. LAY

CHAPEL HILL, NORTH CAROLINA

SCIENTIFIC BOOKS

The Stars of High Luminosity. Harvard Observatory Monograph No. 3. By CECILIA H. PAYNE. New York and London, McGraw-Hill Book Company, Inc., 1930, 8-vo. pp. ix, 320. Price $3.50.

IN 1925, Miss Payne published her first book on "Stellar Atmospheres" as No. 1 of the series of Harvard Monographs. The volume had a notable success. Not only astronomers, but also physicists and physical chemists found in it a much-needed summary of the maze of observational data which had accumulated since the discovery of the spectroscope. The theory of ionization was then less than five years old, and it was particularly appropriate to discuss the data from the point of view of the new theory. Since that time more than five years have passed. The theory has been greatly extended, the technique of measuring the intensities of spectral lines has been improved and adapted to the requirements of the theory, and a great amount of observational material has been accumulated. Since "Stellar Atmospheres" is now out of print and many parts of it out of date, Miss Payne has written an entirely new book which is to supersede and to complete her earlier volume.

The title of the new book is somewhat misleading. It covers a far wider ground than its narrow, perhaps even slightly artificial name, "The Stars of High Luminosity," might indicate. It is in fact a "physical study of stars by means of their spectra," as the first sentence of the book states, and it covers the subject of "Stellar Atmospheres" no less completely than did her first work.

The new book covers an epoch in observational astrophysics. It is one of those rare books that treat a whole field of knowledge from the purely scientific point of view and do not attempt the impossible in catering to the professional astronomer and to the layman at the same time. In a volume of 320 pages, neatly printed on excellent paper, Miss Payne has given a summary of her work and her ideas on the subject of the physical interpretation of stellar spectra. In a clear and vivid style she has given an account of the ionization theory and of various related subjects, primarily from the observational point of view. Being purely "scientific," a layman will get little out of it, but it will be highly appreciated by the scientific world. Astronomers, and perhaps even to a greater degree physicists and chemists, will find here a collection and a critical analysis of the many important facts that observations of stellar spectra have revealed.

The point of view which the author adopts in her new book is distinctly less objective than the one used in "Stellar Atmospheres." Apparently her intention has been more to give an account of her individual research rather than a balanced summary of all knowledge on the subject. As she states in the introduction: "It (the book) carries the work as far as I believe it can be carried with the kind of material available to me—spectra of comparatively short dispersion, either unstandardized or standardized by simple and unrefined methods."

The book falls naturally into four major parts. In the first the author discusses briefly the methods employed in modern spectro-photometric investigations, and the theoretical foundations of the work.

It has been known for some time that stellar absorption lines are not infinitely narrow, nor do they cut out all of the light from the continuous spectrum. Careful analysis has revealed that some lines are wide, while others are narrow; in some the amount of radiation that is cut out from the continuous spectrum is great, while in others it is small. The first task of the investigator is to measure the contours of the absorption lines and to attempt to obtain from these measurements information concerning the physical character of the outer atmospheres of the stars. Physical theory has been helpful in this respect. Through the work of Unsöld and of Stewart, to name only two of the whole succession of brilliant physicists who have worked on this problem, we have definite information as to the manner in which an atom absorbs when it is struck by a quantum of light: it appears that certain very definite laws concerning this absorption can be formulated, and from them important conclusions can be drawn with respect to what is called "the number of active atoms in the atmosphere of a star." In reality this number refers to all the atoms above a certain level in the atmosphere, and E. A. Milne has shown how this level can be determined. Miss Payne adopts the method of expressing her measurements in numbers of atoms, and all of the results contained in the book are more or less closely related to this procedure.

The second part of the book is entitled "The Material." This does not refer to the spectroscopic data resulting from her measurements, for these form the essence of the following part, "Results of Observation." She discusses the character of the stars which she has investigated, and defines the meaning of the term "stars of high luminosity." There is some uncertainty in the distinction between stars of high luminosity and stars of low luminosity, but a line must be drawn somewhere and Miss Payne places it at absolute magnitude -2.0. The book is primarily concerned with stars which are brighter than this value, but since her method involves a comparison of luminous stars with normal stars, she has included in her discussion virtually all types of stellar spectra.

The nucleus of the book is Part III entitled "Results of Observation" and covering a total of 190 pages. The various spectral types are taken up one by one, and the spectral differences between normal stars and high-luminosity stars are discussed for the more conspicuous spectroscopic features. The inclusion of a separate chapter on "The Variable Star" seems especially appropriate. This chapter more than any of the others illustrates how much remains to be done on the subject of high-luminosity stars. There are many correlations and an even greater accumulation of observational data. But no clear understanding of the nature of a "variable star" is as yet available.

In the chapters that deal with the earlier spectral types one is struck by the change in the temperature scale for the hottest stars, compared with the one adopted by Miss Payne five years ago. It has usually been believed that early B-type stars have a temperature in their reversing layers of the order of 20000 °C. Miss Payne now adopts the very much lower value of 13200°. The reason is obvious. The theory of ionization, as used in the method of maxima of Fowler and Milne, does not directly yield the temperature. It can and does establish a certain relationship between pressure and temperature, but one of these two factors must be known beforehand, only in that case can the other be evaluated. The work of Fowler and Milne has pointed this out very clearly. It was only a reasonable guess, an assumption, on their part that the pressures in all reversing layers, irrespective of spectral type, were of the order of 10^{-4} atm. Assuming this to be true the old temperature scale was derived. But there is no reason to believe that the pressure must be the same in all types of stars. In the later types, approaching the sun, we depend upon the energy-distribution of the continuous spectrum to give us the temperature. The pressure is then derived from the ionization formula. In order to be consistent we should adopt in earlier spectral classes, too, the temperatures as given by the energy-distribution, and then determine the pressure. The result is surprising. The energy-distribution points unmistakably to very low temperatures for many of the stars of earliest spectral types, and the resulting pressures are of the order of 10^{-13} atm. There is a large amount of evidence against such low pressure and Miss Payne very correctly rejects this interpretation. We are left with the disquieting necessity of doubting the evidence of the continuous spectra: the distribution of the energy as a function of wave-length does not give us the true temperatures of the stars. But what is then left of our temperature scale? On the one side we are not willing to adopt equal pressures for all spectral types; on the other we find that what we thought was the only trustworthy method of deriving stellar temperatures is giving us erroneous results. The first problem is, of course, to investigate the causes which make the method fail. Is it due to a real failure of the light of the stars to conform to the radiation law of black bodies, or is the light of the stars changed in passing through interstellar space? Miss Payne adopts the first alternative and dismisses the second rather briefly. But her reasons for doing so are perhaps not binding. She suggests that there is a departure from black-body radiation which makes itself manifest in the form of a violet depression in the more luminous B-type stars. If the color temperature is determined from the range of wave-lengths affected by the depression, we should obtain low temperatures. On the other hand, were we to go further into the ultra-violet, we should gradually come back to the true temperature distribution, and no anomaly would be observed. This idea the author supports by the statement that the photoelectrically determined color-indices by Bottlinger show less reddening effect than direct spectro-photometric measurements made at Harvard for the same stars. She suggests that this is due to the difference in color-sensitivity of the two methods: the sensitive point of Bottlinger's measurements being to the violet of that of the Harvard measures. But is this really so? Bottlinger used a potassium cell with a violet filter having maximum sensitivity at λ 3650. The whole instrument was attached to a refracting telescope. Surely the maximum sensitivity of the combination could not have been much to the violet of λ 4000, and indeed, Bottlinger himself suggests that the radiation to the violet of this point was without effect upon his measurements.[1] Compare this with the recent spectro-photometric results of Trumpler (not available when Miss Payne's book was written). Here a quartz spectrograph was used attached to a reflector. The microphotometer curves extend to about λ 3400, and no evidence of any depression is visible. But the effect of reddening is very pronounced.

[1] Sensitivity curves for Bottlinger's measurements are given in Handbuch der Astrophysik 2, 361, 1929. The maxima are at λ 4300 and λ 4700.

The crucial test would, of course, consist in the determination of color-temperatures of groups of stars in open clusters, where all the members are known to be at the same distance. If the hypothesis of Miss Payne is correct, the more luminous stars should show more pronounced reddening than the less luminous stars of the same spectral types. If Trumpler is right, the amount of reddening should be the same for all stars. Miss Payne mentions in this connection the work of Balanovsky and states that there is some evidence in his results favoring her point of view, but she states that "quantitative estimates of the temperature can not be made from his discussion."

Incidentally it may be noted that there is a correlation between reddening of B-type stars and intensity of the interstellar calcium lines, and, contrary to the statement of Miss Payne's book on page 120, there is a very pronounced concentration of red B-type stars in the very region where some of the strongest interstellar lines are observed (in the constellation Cepheus and in adjoining regions). But this does not mean that the reddening may be caused by the calcium itself: the amount of matter, in the form of ionized calcium, in the line of sight between the observer and some of the most distant stars is not more than is contained in one cubic centimeter of air at normal pressure and temperature. It is clear that so small an amount of matter could never produce the enormous amount of reddening observed by Trumpler and by others.

Whatever the outcome of this extremely interesting problem may be, we are left with the unsatisfactory state of our present temperature scale. Future work will have to deal with this side of astrophysics, and will have to devise new methods by which this scale may be ascertained. If the reddening should turn out to be due to interstellar absorption, then there would be no reason to question the radiation laws. The nearer stars would give us more nearly correct temperatures than the more distant stars, and an extrapolation should enable us to get the energy-distribution for zero distance. If, however, space reddening is not present, the matter would be more complicated. Perhaps the study of the Stark effect in stellar spectra may help to establish another function of temperature and pressure. It should then be possible from this and from the ionization formula to evaluate pressure and temperature independently. Even now it is possible to say, from the Stark effect alone, that pressures of the order of 10^{-13} atm. are not possible, and that consequently the energy-distributions can not be taken at their face value. An independent determination of the temperature scale could perhaps be obtained by a method similar to the one used by Adams and Russell in 1928.

Speaking of the ionic Stark effect, it is of interest to note that Miss Payne finds evidence of its existence, at least in spectral class A. The question might justly be asked: if ionic Stark effect is present, is it permissible to apply the Unsöld formula to the evaluation of the numbers of atoms? Strictly speaking the absorption coefficient in a line affected by Stark effect is not that given by the classical theory (as was pointed out by Unsöld) and the formulae which may be used for lines produced by radiation damping are not applicable. But it is fairly safe to say that the discrepancy will not be a serious one and that the numbers obtained will at least be comparable to those that would apply in the case of no Stark effect.

The last part, "Analysis of Stellar Atmospheres," gives a short summary of the observational results described in the preceding chapters and discusses them, rather briefly, in the light of the "generalized" ionization equations of Milne.

There are many useful tables in the book. A complete list of O stars, a catalogue of stars showing the so-called c-characteristic in their spectra, and a list of Cepheid variables add greatly to the value of the volume.

O. STRUVE

YERKES OBSERVATORY,
WILLIAMS BAY, WISCONSIN

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A NOTE ON CAPSULE STAINING

SOME difficulty in securing good results is frequently encountered in the routine laboratory exercise on staining capsules by the well-known method of Hiss.[1] In an effort to make this procedure more adaptable to class use several variations have been tried and a series of dyes compared by various procedures. The dyes tested were as follows: crystal violet, 84 per cent., crystal violet, 92 per cent., crystal violet (dye content not stated), methyl green, gentian violet, methyl violet 1 B, methyl violet 2 B (two brands) and aniline violet. The organisms were pneumococcus from the peritoneal cavity of an infected mouse and Klebsiella pneumoniae from serum agar slants. Thin smears were made without the use of a diluent; the films were allowed to dry in the air and stained without fixation.

Methyl green was not found to be a satisfactory stain by any of the procedures tested. More or less

[1] P. H. Hiss, Jr., "A Contribution to the Physiological Differentiation of Pneumococcus and Streptococcus, and to Methods of Staining Capsules," *Jour. Exper. Med.*, 6, 317, 1905.