might perhaps be further limited by methodological principles.

In the first chapter, the author gives an erudite discussion and sometimes a bold exegesis of opinions of distinguished pre-relativistic and relativistic writers. His arguments are repeated and elaborated in chapter three in an emotional debate with H. Putnam. Those readers who happen to become interested in the personal scores in the Grünbaum–Putnam competition may feel obliged to get hold also of Putnam's complete paper[2], although chapter three contains many quotations from it, just as from the complete first chapter. To my taste, the book would have been more readable if the collection of papers had entirely been rewritten in a more methodical and less rancorous manner. But above all, I should have preferred to see the concepts and problems more clearly formulated by all debaters in proper mathematical terms and in the context of rational physical theories.

A key to relativity theory is the study of transformations of equations of observable phenomena under certain transformations of basic reference quantities such as the coordinates x^α and the metric tensor $g_{\alpha\beta}(x)$. Conventional theories impose the condition of local invariance of $g_{\alpha\beta}(x)\ dx^\alpha\ dx^\beta$, so that the transformations of $g_{\alpha\beta}(x)$ are determined by those of x^α. $g_{\alpha\beta}(x)$ is considered to be determinable from a number of suitable observations with, for example, rods, clocks and light rays in every point x. That requires corrections for differential effects depending on the specific constitution of the instruments and perhaps explicit or implicit conventions on universal effects. The book is concerned with the fundamental problem of revealing such conventions and with the question how they might be changed. The disputations offer perhaps a challenging introduction to this programme. But I think, in order to carry it through, or to appreciate its interest, a precise analysis would be necessary in the context of some definite theory of gravitation and in mathematical terms, involving a.o. independent transformations of x^α and $g_{\alpha\beta}(x)$ without the invariance condition and perhaps with some compensating gauge fields. I expect that a precise formulation would hardly leave room for Grünbaum–Putnam controversies like that about "universal or differential" "forces".

The answer to various fundamental problems of space and time depends on the specific relativistic theory or even cosmological model. Theories of special and general relativity make it, for example, possible to understand interweaving and curvature of space and time. The topology in the large of a spatially open or closed universe imposes restrictions on the metric $g_{\alpha\beta}(x)$. It must be granted that gravitation theories are highly hypothetic and cosmological models still more speculative. That implicates that our philosophical ideas about space and time are also bound to be hypothetic. They are radically changing under the development of physics and perhaps cosmology.

Physical theories of space and time need philosophical clarification of their basic concepts. On the other hand, philosophy of space and time needs a concrete physical basis. There seems to me a gap between present day physics and the primitive physical reasonings in this philosophical book so that even the most brilliant arguments pro and con are not convincing. I do not think I could estimate *in merito* Grünbaum's profound ideas about the fundamental state of the metric in the topology of physical space-time as long as they have not been expressed, with the help of a precise mathematical formalism, in the clear context of specific physical theories.

H. J. GROENEWOLD

[1] Grünbaum, A., *Scientific Explanation, Space and Time* (edit. by Feigl, H., and Maxwell, G.) (Minnesota Studies in the Philosophy of Science, 3), 405 (University of Minnesota Press, Minneapolis, 1962).

[2] Putnam, H., *Philosophy of Science. The Delaware Seminar*, 1962–1963 (edit. by Baumrin, B.), 2, 205 (Interscience (Wiley), New York, 1963).

[3] Grünbaum, A., *Boston Studies in the Philosophy of Science* (edit. by Cohen, R. S., and Wartofsky, M. W.), 5, 1 (Reidel, Dordrecht, 1968).

OBSERVING THE UNIVERSE

Practical Work in Elementary Astronomy

By M. G. J. Minnaert. Pp. xxiii + 247. (Reidel: Dordrecht, 1969.) 35 florins.

THIS is a unique and valuable collection of practical exercises developed over a period of 25 years of teaching to first year undergraduates at Utrecht Observatory. As would be expected, it is orientated towards an understanding of astronomy as a whole rather than merely to specialized observing techniques. It is therefore suitable, not only for honours astronomy, but also for students taking the subject as a one year ancillary to physics or mathematics.

There are obvious problems, peculiar to astronomy, in organizing practical work. These have been well recognized here. Fifty of the seventy-four exercises, involving only the reduction of data, can be carried out entirely indoors. This allows a laboratory to be conducted at regular times in the afternoons and evenings, the class being switched to the schedule of twenty-four sky exercises as the opportunities arise. Each exercise can be completed by a pair of students in about three hours. Because an individual student can only complete some twenty-five exercises during the year, a list of seventy-four amply provides the flexibility essential for this kind of operation.

Some duplication is necessary for sizable classes, and the equipment has therefore been kept as inexpensive as possible throughout. The small telescope used in the sky exercises, and even the simple microphotometer, for example, can be made in a small workshop. It is notable that the Doppler effect is demonstrated by a spectrogram of Saturn instead of with a stellar spectrogram, thereby avoiding the use of an expensive travelling microscope.

While the course is intended for first year work, many of the exercises involving the reduction of data and computation, such as the three-body problem, or the derivation of the elements of an eclipsing binary star, or the construction and application of a curve of growth, involve theoretical concepts somewhat advanced for first year students.

Some of the laboratory simulations are novel. Students will particularly appreciate the Bénard cell experiment. On the other hand, some opportunities seem to have been missed. Having introduced the principle of using the observatory workshop, it is not too big a step to the construction of artificial double stars or star fields, together with a simple telescopic camera. Admittedly, some students find simulations of direct observational procedures difficult to accept; it may be that these have been avoided at Utrecht for that reason.

Although the material has been presented in sufficient detail for direct use by the student, the principal impact of the book will be on teaching staff developing practical courses. In this respect, the most important and valuable features of the work are the data cited for each exercise, in the form of references to the literature and to star charts and atlases. It must be remarked, however, that much of this material is readily available only in an observatory library.

P. A. SWEET

PHYSICAL MASS SPECTROSCOPY

Mass Spectrometry and Ion-molecule Reactions

By P. F. Knewstubb. (Cambridge Chemistry Texts.) Pp. vii + 136. (Cambridge University Press: London, June 1969.) 40*s*, \$7.00 cloth; 15*s* paper.

THE rapid growth of mass spectroscopy during recent years has involved workers from a variety of disciplines. Consequently, there is a need for introductory texts, a need already satisfied to a large extent in the case of