attention was called to circular shadows on the rocks and the bottom of the stream. These shadows varied in size from about one inch to one and one half inches in diameter. Around the outer edge of the shadows was a halo and occasionally faint rotating streamers.

The water was quite clear and it was perfectly obvious that floating objects were not responsible for the shadows. It was observed that the shadows came from vortices and, further, that these vortices depressed the surface in such a manner that the light, falling in the vortex, was deflected outward somewhat, as in the concave lens.

This is simply one of those interesting phenomena which I never happened to observe previously. I am thinking that perhaps others who read this may find one additional thing to look for when they are in the open.

F. C. BROWN

MUSEUMS OF THE PEACEFUL ARTS
NEW YORK, N. Y.

PLANETARY SYSTEMS

IN his retort to Professor Porter, who had criticized him for saying that planets like those of the solar system are rare, though there are millions of stars more or less similar to our sun, Professor Arthur H. Compton seems to feel that he fully justifies his position by citing as his authority the distinguished theoretical astronomer, Sir J. H. Jeans.

Doubtless Professor Porter overstates his case in claiming that "there is absolutely no reason for the assumption that the formation of attendant worlds may not be the ordinary course of evolution for the single stars." On the other hand, it must be recognized that Jeans's conclusion is based upon highly theoretical assumptions and should not be given too much weight. It is to be feared that Professor Compton has erred in asking his readers to accept as a demonstrated fact what is in actuality little more than an educated guess.

G. B. BLAIR

UNIVERSITY OF NEVADA

SCIENTIFIC BOOKS

The Size of the Universe: Attempts at a Determination of the Curvature Radius of Spacetime. By DR. LUDWIK SILBERSTEIN. viii + 215 pp. Oxford University Press, London, 1930.

THE problem of the curvature of space was born directly out of the relativity theory of gravitation and was therefore first raised seriously by Einstein, who was led to adopt as a basic geometry of the universe one of constant curvature in space, leaving the time coordinate "straight." De Sitter, on the other hand, contemplated another possibility, in which the four-dimensional world is perfectly spherical, the time being curved along with the space coordinates. These two possibilities are generally referred to as Einstein's cylindrical world and de Sitter's spherical world, and they fairly exhaust the worlds of constant curvature.

Does our own world belong to the class of constant curvature, and, if so, is it of the cylindrical or the spherical class, and what is the actual value of its radius of curvature? These are the questions Dr. Silberstein sets out to answer.

The first part of the book is concerned with the general theory of curved surfaces, the theory of tensors and the relativity theory of gravitation. The second part is devoted to a discussion of the relative merits of Einstein's and de Sitter's worlds. The third part contains an extensive, and rather unexpected, criticism of Dr. Hubble's estimate of the world radius corresponding to Einstein's cylindrical world. The fourth and fifth parts are concerned with the Doppler effect in de Sitter's world and how this may be used to find the world radius from an analysis of the radial velocities of the stars. This latter problem is also the subject of miscellaneous notes at the end of the book.

The reader is likely to finish this book in a state of mingled admiration and depression. Its every page bears witness of a strong personality, and the formal style is unusually clear and attractive. The introductory chapter on non-Euclidean geometry is, in particular, a product of fine, artistic beauty. On the other hand, the book is written exclusively from Dr. Silberstein's personal point of view, and as this frequently runs opposite to the opinion of other authorities the reader will have to do a lot of reading in the general literature in order to be fully informed on the subject. For an astronomer it is especially disconcerting to read the last part and the notes. In fact, to search for the de Sitter-Doppler effect in the motion of the nearer stars seems, to put it mildly, like hunting for a needle in a haystack. Considering that in this search much more pronounced peculiarities in the laws of stellar motion have been sacrificed, Dr. Silberstein can scarcely blame the astronomers for having little faith in his results.

So much has been written about the curvature of space, both in scientific journals and in the press, that a separate book on the subject should meet with general approval. The present book seems more calculated to stimulate than to satisfy this demand. This may be fortunate, as, according to some recent work of Abbé le Maître and of Eddington, the problem may be more complicated than was believed previously. In fact, the universe may, perhaps, not at all possess a constant world curvature; and it must be admitted that the preponderantly positive radial velocities of the spiral nebulae are most simply explained by assuming the whole universe to expand, and to have nothing to do with the de Sitter-Doppler effect.

On the whole, the subject of the curvature of space is one in steady progress, the present state of which does not encourage to any display of orthodox convictions, but which may become of considerably more cosmologic importance in the near future.

SVEIN ROSSELAND
OSLO UNIVERSITY OBSERVATORY

Determination of Orbits of Comets and Asteroids. By RUSSELL TRACY CRAWFORD. xi + 233 pp. McGraw-Hill Book Company, 1930.

A TEXT-BOOK designed for a college course of one semester to provide an introduction to the subject of orbit determination. The following subdivision of the book could be made: (*a*) Introductory chapters treating the motion of a body about the sun as attracting center, also including the subject of ephemeris computation; (*b*) Leuschner's method of orbit determination; (*c*) Merton's modification of the Gaussian method of orbit determination. Completely worked out examples and summaries of formulas for both methods and fourteen auxiliary tables are added.

As the author states in his preface, this work is different from other treatises on orbit computation. It is not intended to be complete, and does not, for instance, include the mathematical development of precession, nutation, special perturbations or least squares. "The definitive orbit" is very briefly treated, but logically, considering the fact that the book treats undisturbed orbits only.

Notwithstanding limitations set by the scope of the book, it is complete enough to be a very useful reference book. Those interested in more intricate problems, mainly of theoretical importance, which could not be fully treated, will find many helpful references to original publications.

This is the first time that a coherent presentation of Leuschner's method is published, after the original publication in Vol. VII of the Lick Observatory Publications. (Buchholz-Klinkerfues, 1912, gave little more than a set of formulas and examples.) Especially because many treatises on orbit computation entirely disregard the existence of other methods than the Gaussian we could have been satisfied with a book presenting Leuschner's method only. The fact that two methods, one representing the Laplacian and the other representing the Gaussian method, are given testifies to the broad attitude taken by Leuschner and his followers.

That Merton's development of the Gaussian method is chosen is not surprising. It has done away with a number of complications mainly due to the former necessity of adapting all formulas to logarithmic computation. The two methods offered are undoubtedly distinguished by theoretical clearness and adaptation to practical needs.

It would have been impossible within the scope of the book to include a critical comparison of methods of orbit computation. This is left to the student. The field which this book covers is very large, so that a selection was necessary. The author has made an admirable choice guided by his expert knowledge of the subject and experience in teaching it.

The book is beautifully printed; one can only wish that the subdivision of the chapters had been made more uniform and more distinct. The generous size of the pages (10 x 7 inches) has contributed much to its fine appearance, as many long formulas had to be included. The book is dedicated to Professor A. O. Leuschner, "a most stimulating teacher and inspiring director."

DIRK BROUWER
YALE UNIVERSITY OBSERVATORY

SCIENTIFIC APPARATUS AND LABORATORY METHODS

AN OBJECTIVE METHOD OF EVALUATING MUSICAL PERFORMANCE

IN the psychological laboratory of the University of Iowa we have developed instruments which enable us to record actual singing and playing accurately and quickly. This is done mainly with the strobophotograph camera designed by Professor Milton Metfessel[1] and recently improved by Tiffin and Reger. It virtually graphs two of the four elements of musical performance, namely, pitch and time. The other two elements, intensity and timbre, are not recorded.

A stroboscopic disk runs between the film and a neon lamp. The lamp flashes in frequency with the sound wave, and the film, moving past at a constant speed, registers a continuous picture of the stroboscopic effect. The stroboscope registers in terms of tenths of a tone but finer readings may be made in proportion to the steadiness of the tone.

The object of this note is to illustrate how this

[1] *Jr. Gen. Psychol.*, 2: 135–139, 1929.