"Fermi's taste for simple presentation in his scientific work does not represent his state of knowledge," which was always profound with exceptional physical insight.

A convocation address contains, briefly, Wigner's philosophy of life. He points out that mankind always lived in some sort of man-made predicament. We must have courage "to face today what must inevitably be faced tomorrow . . . among these things is death." Another reflective essay mentions nostalgically in how much better position the United States would be today if it had developed the bomb in 1943–44 instead of 1944–45. In the same article he admits not to have either emotional or intellectual pangs of conscience for his role in the establishment of the chain reaction "because the nuclear chain reaction was bound to be achieved in any case, and I shudder at the thought that it might have been discovered first by an aggressive nation rather than our own." In another essay (from 1961) disarmament is discussed with the forthright realism that is characteristic of the author.

The first and last article reflect the author's deep preoccupation with the direction of future science. During the war he was one of the great leaders in the *big* (applied) *science* that heralded the atomic age. Nevertheless in pure research his heart is with *little science*. The overorganization of science "could destroy the detachment and sublime satisfaction that is the reward of the scientist of our period . . ." He realizes, of course, the present very strong trend toward big science, with big machines, but he also feels that vigorous support of big science should be coupled with encouragement and high esteem for little science. He calls this a "middle-road" approach. This should appeal, this reviewer feels, even to those who do not share the author's somewhat critical attitude toward certain trends of present high-energy physics.

These essays, particularly his convocation speech at the U. of Alberta, reveal Wigner not only as a great scientist but also as a man of action who is always willing to fight for his convictions. During the war he pushed through his idea of a water-cooled reactor for Hanford against considerable opposition. He *knew* he was right, and he did not mind fighting. More recently he started a civilian-defense project at Oak Ridge. Although I may not agree with all of Wigner's ideas about civilian defense, I admire the persistence and skill he displayed in setting up such a project, for which at present it is not easy to obtain public support.

Wigner is also quite willing to postpone some of his own scientific work in favor of something of more general national interest. Thus in 1957–58, although he was considerably interested in some problems of nuclear physics, he collaborated with Weinberg on the book *The Physical Theory of Neutron Chain Reactions*, and finished it in time for distribution by the American delegation at the 1958 Geneva atoms-for-peace conference.

Science, Wigner says, "gives coherence to human society and fires it to a purpose." "The promise of future science is to furnish a unifying goal to mankind rather than merely the means to an easy life, to provide some of what the human soul needs in addition to bread alone. If it can fulfill this function, it will play one of the great roles in the drama of mankind." This book fulfills this function!

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Eugene Guth has been a technical advisor to the director of the Oak Ridge National Laboratory since 1955. Previous to this he was a research professor at Notre Dame. Besides having worked on polymers, solids and nuclei, he also worked on the history and philosophy of physics.

Metric, topology, relativity and symbolic logic

A DEDUCTIVE THEORY OF SPACE AND TIME. By S. A. Basri. 163 pp. Interscience, New York, 1966, $7.00

PHILOSOPHICAL PROBLEMS OF SPACE AND TIME. By Adolf Grünbaum. 448 pp. Alfred A. Knopf, New York, 1963. $7.50

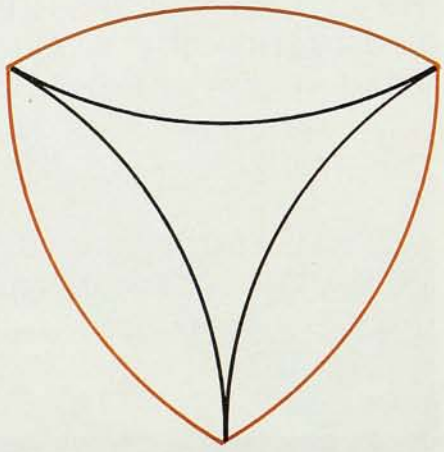
by R. Bruce Lindsay

The fundamental ways of categorizing human experience, known as space and time, have long been the preoccupation of philosophers and mathematicians, and since the advent of relativity have attracted increased attention from physical scientists. That they are elusive concepts demanding the most profound examination that the human intellect can bring to bear is made abundantly clear in the two books under review.

Adolf Grünbaum, the distinguished philosopher of science of the University of Pittsburgh, has provided a very searching inquiry into the philosophical problems of space and time arranged for convenience in three main parts, namely, those relating to the metric, the topology and the relativistic aspects, respectively. His treatment mingles philosophy and history in effective fashion, since although he could not be expected to pay attention to the views of all important philosophers and scientists who have done research on the subject, he does consider in detail people like Isaac Newton, Bernhard Riemann, Henri Poincaré, Pierre Duhem, Arthur Eddington, Percy Bridgman and Bertrand Russell, as well, of course, as Albert Einstein and the more recent relativists. The author's critique is in every case extremely searching and in many cases appears to reach the polemical level. It is clear he feels very deeply the importance of securing the utmost in logical validity throughout his theme. Probably not many physicists will care to follow him all the way in this endeavor, though they may applaud his zeal.

In the part on the metric of space, much emphasis is placed on the idea of congruence and the question of whether it is something forced on the mind by experience or whether it is conventional in character. In the dis-

NONEUCLIDEAN GEOMETRIES of Lobatchewsky and Riemann (color).



cussion Poincaré seems to come out on top, for it is clear that the author believes his conventionalism is the only reasonable attitude (so does the reviewer!). The same trend of thought continues in the examination of the nature of geometry and the extent to which we can specify it through physical theory and experimentation.

The 160 pages of the part on topology are devoted almost exclusively to time. There is an elaborate examination of the causal theory of time, in accordance with which time is inextricably connected with the succession of cause and effect. This will probably make little impact on physicists, who have long since abandoned the notions of cause and effect in favor of a concept of causality of their own. The section on the attempts to demonstrate the anisotropy of time by physical means, for example by statistical thermodynamics, are of decidedly greater interest. The author concludes that the usual attempts to prove anisotropy from statistics are illusory but believes he can save the idea by the introduction of the notion of "branch not interfere with overall entropy prosumers for limited time periods, but do not interfere with overall entropy production in the larger systems of which they are a part. Grünbaum has a strong belief that in any case the anisotropy of time cannot provide definite knowledge that time flows one way, and he bolsters his view by an ingenious set of arguments.

In the final part of the book the author pays his respects to philosophical problems involved in the theory of relativity, particularly with reference to the assumption of the constancy of the velocity of light (in free space) in all inertial systems and the role of the velocity of light as the maximal velocity at which energy can be transferred in our universe.

Grünbaum's volume contains a great deal that should be of value to any physicist interested in the foundations of his science, though it must be confessed that it is not by any means easy reading. The author could have materially assisted the reader by providing a brief summary of his main conclusions at the end of each section. Another drawback to the book is the almost negligible index.

Coming now to the book by S. A. Basri, a member of the physics staff of Colorado State University, we note that the author's expressed aim has been to provide a foundation for a *single* deductive theory on which all of physics could be built. The present volume is essentially the first part of his program since he agrees that any physical theory must have as its basis an adequate way of handling space and time. He begins by making clear what he means by a deductive theory, and this is in consonance with the usual interpretation. He has chosen to cast his subsequent development in the terminology of symbolic logic with only brief summaries of what his results mean in ordinary language. The author's principal achievement is the construction of a space–time geometry based on general relativity but differing from the latter in certain important respects. For example, no method is given for the calculation of the metric coefficients, which in general relativity is carried out by means of the field equations and the energy-momentum tensor. The book contains an appendix devoted to a brief and elementary presentation of the terminolgy of symbolic logic and set theory. Further development of the author's ideas will be looked for with interest by philosophers of physics.

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Orbits: theory and practice

AN INTRODUCTION TO ASTRODYNAMICS. (2nd edition) By Robert M. L. Baker Jr, Maude W. Makemson. 439 pp. Academic Press, New York, 1967. $11.75

ASTRODYNAMICS: APPLICATIONS AND ADVANCED TOPICS. By Robert M. L. Baker. 539 pp. Academic Press, New York, 1967. $16.50

by Robert E. Street

Astrodynamics is defined as the application of celestial mechanics to the determination of the trajectories of space vehicles, either by precomputation of the desired path or by determination of the orbit after the vehicle is launched. When the first edition of this *Introduction* was published in 1960, courses in astronautics were just beginning to be organized in this country. Most instructors were basing their courses upon notes taken from the classical texts in celestial mechanics together with relevant material from aerodynamics, geophysics, navi-