Matter and mind

SYMMETRIES AND REFLECTIONS: SCIENTIFIC ESSAYS. By Eugene P. Wigner. 280 pp. Indiana U. Press, Bloomington, Ind. 1967. $7.50

by Eugene Guth

Eugene P. Wigner's scientific essays—collected in this volume—display the same profound insight and great versatility as his original research work. They mirror his extraordinary wide interest in everything basic. He raises stimulating questions about epistemology and quantum mechanics, the nature of life and the role of consciousness. He also discusses his ideas about general topics such as disarmament and the economy of nuclear power.

The articles were written over the last 30 years and were intended for diverse audiences, ranging from readers of *Reviews of Modern Physics* to those of the *New York Times Magazine*! They are grouped into four chapters dealing with symmetry, nuclear energy, epistemology and quantum mechanics, and reflections. Some of the essays, particularly those in chapters 1 and 3, presuppose a considerable knowledge of physics. The conclusions are always formulated with critical clarity, however, so that a wide group of attentive readers will find a large part of the book comprehensible and rewarding.

The first five essays center on symmetry. The "Father of Symmetry" tells us his deep thoughts on events, laws, invariance principles and conservation theorems. It is characteristic of Wigner that even in such general essays he will introduce new physical ideas. For example, the first article contains the first suggestion of the baryon conservation law in conjunction with the group of strong interaction and a detailed discussion of the conservation of electric charge based on the electromagnetic gauge group.

We are told that the specification of the explainable may have been ". . . the greatest discovery of physics so far." The laws of nature refer to "the regularities of the events," that, hopefully, "are clearly separable from the . . . initial conditions, in which there is a strong element of randomness." In "organized motion," for example, Bode's law about the regularities in our planetary system and "even the existence of life," science attempts to connect with some initial randomness. Finding the minimal set of relevant initial conditions will yield maximal physical understanding.

We learn that already in classical physics one should distinguish sharply between the geometrical invariances connected, for example, with the Galileo, the Poincaré, or the de Sitter group, and the dynamical invariances related to the respective (gauge-type) groups of, for example, electrodynamics and general relativity. The crossing relations are considered as an example of a transition between geometrical and dynamical invariances. "One may hope that they will help establish a link between the now dis-

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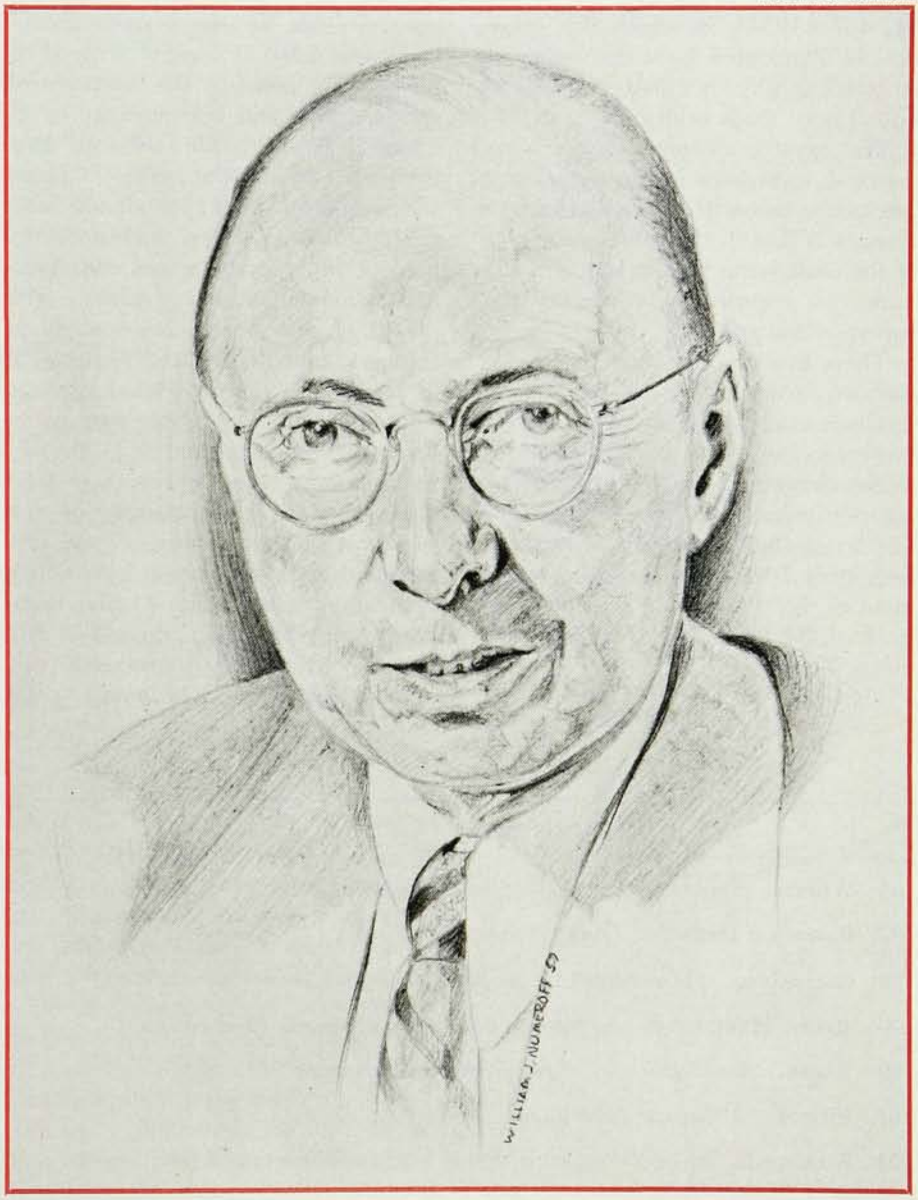

joint geometrical and dynamical principles of invariance."

We read that the concepts of general relativity, essentially, have macroscopic character. Instead of yardsticks, a set of clocks is used as the "simplest framework in space–time, and the one which is most nearly microscopic." The quantum limitations on the accuracy of the clocks lead to the conclusion that general relativity and quantum theory are difficult to reconcile. Let us add that the problem of the quantization of general relativity is still unsolved. In spite of ingenious attempts there are still theorists who do not see a compelling reason for a quantization of the gravitational field.

The relation between the laws of motion and conservation theorems in classical mechanics depends to a large extent on the specific form of Newton's laws. Since this fact is perhaps not generally known, we wish to refer to Wigner's paper in *Progr. Theor. Phys.* **11**, 437 (1934), in which this question is illuminated by a discussion of Aristotelian physics (gradient of force equals mass times velocity).

The greater richness of the geometrical invariance laws in quantum mechanics in contrast to classical mechanics is due to the linear character of the underlying Hilbert space of the latter, as regards, for example, the superposition principle.

These five essays should be recommended reading for all advanced graduate students of physics—for their professors too! The other two articles of this chapter discuss solid-state physics, particularly the four different lattice types (metals, molecular, valence and ionic lattices) and the development of the concept of the compound nucleus, the latter being a 1955 Richtmeyer lecture.

The next chapter of four essays deals with nuclear energy. The essays are partly historical, partly very clear pure physics (radiation effects in solids, jointly with Frederick Seitz), partly a plea (jointly with Alvin M. Weinberg) for "breeder reactors" instead of "burner reactors" for the long haul.

There follow essays on epistemology and quantum mechanics. The problem of measurement in quantum mechanics is profoundly illuminated from the "orthodox" point of view to which Wigner adheres. However, he does display an uneasiness about some conceptual weaknesses of this view. "*. . . measurements which leave the system object-plus apparatus in one of the states with a definite position of the pointer cannot be described by the linear laws of quantum mechanics.*" Existence of such measurements would force us to abandon the superposition principle. Wigner also believes that ". . . it was not possible to formulate the laws of quantum mechanics without reference to the consciousness." We come here in contact with Wigner's strong belief in the existence of consciousness and the necessity of its scientific study. He believes that there are two kinds of reality. "These are so different that they should have different names. The reality of my perceptions, sensations and consciousness is immediate and absolute. The reality of everything else consists in the usefulness of thinking in terms of it; this reality is relative and changes from object to object, from concept to concept." He suggests: (1) the observation of infants "where we may be able to sense the progress of the awakening of consciousness," and (2) the discovery of phenomena "in which the consciousness modifies the usual laws of physics." He adds, "The first type of observation is constantly carried out by millions of families, but perhaps with too little purposefulness. Only very crude observations of the second type have been undertaken in the past, and all these antedate modern experimental methods. So far as it is known, all of them have been unsuccessful." (Thus Wigner is not a disciple of parapsychology!)

The last essay of this group, originally written in honor of Michael Polanyi (who directed Wigner's PhD thesis), deals with the nature of life. Calculations from a precisely defined model show that, according to standard quantum mechanics, self replication is improbable. Wigner emphasizes that his calculation is far from realistic; it is based on the assumption "that at least one organism surely survives the interaction with the nutrient. There is no clear reason to believe this. A realistic model would permit, rather, any final state, but would demand that the sum of the probabilities of the states with two living organisms be well in excess of 1/2. This latter model is much more difficult to discuss." Nevertheless Wigner feels that "the arguments presented . . . are suggestive, but not conclusive" for the existence of biotonic laws (an expression introduced by Walter Elsasser), for example, specific laws of biology, which are not included in the (present) laws of physics. However, he admits that "his firm conviction in the existence of biotonic laws stems from the overwhelming phenomenon of consciousness."

There are two touching biographical essays. The one on John von Neumann, a close, lifelong friend, mentions that the school he (and also the author) attended, the Lutheran High School in Budapest "was, at that time, perhaps the best high school of Hungary and probably also one of the best of the world." It also gives particular credit to the mathematics teacher L. Ratz ("to whom the present writer is also indebted"). One seldom hears about the importance of a first-rate high school in the development of a budding scientist, and even more seldom does one hear the name of his deserving teachers. Accuracy of logic, brilliance and exceptional memory characterized von Neumann. His heart-breaking struggle with death is movingly described. The essay on Enrico Fermi emphasizes the man's simplicity, realism, greatness and leadership. He showed an almost superhuman composure in the face of death. The author points out that

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"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).