Wigner's Vast Output: Four of the Eight Planned Volumes

The Collected Works of Eugene Paul Wigner

Part A: The Scientific Papers

Vol. I (no title)
Edited by Arthur Wightman
Springer-Verlag, New York, 1993.
717 pp. $149.00 hc
ISBN 0-387-56560-4

Vol. II: Nuclear Physics
Edited by Arthur Wightman
Springer-Verlag, New York, 1996.
574 pp. $159.00 hc
ISBN 0-387-56972-3

Vol. V: Nuclear Energy
Edited by A. M. Weinberg
Springer-Verlag, New York, 1992.
808 pp. $129.00 hc
ISBN 0-387-55343-6

Part B: Historical, Philosophical, and Socio-Political Papers

Vol. VI: Philosophical Reflections and Synthesis
Edited by J. Mehra
Springer-Verlag, New York, 1995.
631 pp. $148.00 hc
ISBN 0-387-56986-3

Reviewed by Silvan S. Schweber

> I think continually of those who were truly great.
> . . . who in their lives fought for life,
> Who wore at their hearts the fire's center.
> Born of the sun they traveled a short while towards the sun,
> And left the vivid air signed with their honour.
>
> *Stephen Spender*

Reading the four volumes of Eugene Wigner's *Collected Works* that have appeared thus far constantly brings to mind the poem by Stephen Spender quoted above. Only by studying their total output can one appreciate how off-scale were the young giants who laid the foundations of the quantum mechanical description of the microscopic world: Wolfgang Pauli, Werner Heisenberg, Paul Dirac, Wigner, Hans Bethe, Felix Bloch, Lev Landau, Rudolf Peierls, Victor Weisskopf. Wigner stands out by being, on the one hand, the theorist who had perhaps the greatest affinity to pure mathematics and, on the other, probably the most phenomenologically inclined among them. He was not captivated by the great post-World War II advances in quantum field theory, and his scientific papers after the war dealt primarily with nuclear physics, reactor theory, mathematics, the foundations of quantum theory and, in particular, with the quantum theory of measurements. Like Bohr, Pauli and Heisenberg, Wigner was deeply concerned with the epistemological issues raised by quantum mechanics and relativity and by their synthesis. Having his philosophical writings collected in one place makes clear how important and germinal a philosopher of science Wigner was.

Wigner's *Collected Works* have been issued under the careful editorship of Arthur Wightman, and Springer-Verlag is to be commended for the beautiful printing job it did. The eight volumes—of which volumes I, II, V and VI have now been published—will contain all of Wigner's published papers as well as heretofore unpublished materials relating to Wigner's wartime activities. The papers have been divided into two parts: the scientific ones, edited by Wightman, and those dealing with historical, philosophical and sociopolitical matters, edited by Jagdish Mehra.

Each set of articles dealing with a specific subject is introduced by an annotator's informative preface. For example, the papers in volume I dealing with Wigner's "applied" group theoretic methods in atomic, nuclear and solid-state physics (dating from 1926 to 1935) are annotated by Brian R. Judd and those dealing with pure mathematics by George Mackey. Mackey's 50-page essay is a wonderfully lucid introduction to Wigner's seminal papers on unitary representations of compact and noncompact groups and a valuable exposition of the content and import of Wigner's other mathematical works. Mackey also provides some perceptive insights into Wigner's physics papers and makes important statements on the relation and interaction between physics and mathematics.

Herman Feshbach is the annotator for volume II, which contains the scientific papers that constitute Wigner's staggering contributions to nuclear physics: those of the 1930s that laid the foundations for the subsequent descriptions of nuclear structure and nuclear reactions and those of the 1950s and 1960s that extended the earlier papers' scope and generality. The volume also contains Wigner's papers on the statistical distribution of the highly excited energy levels of heavy nuclei, in which he introduced a new kind of statistical mechanics that led him (and others) to study the properties of the eigenvalues of random matrices. Also included is the little known but highly informative survey of nuclear physics that Wigner wrote with Leonard Eisenbud and G. T. Garvey for the 1967 McGraw-Hill *Handbook of Physics*.

It is volume V, dealing with nuclear energy and annotated by Alvin Weinberg, with the assistance of Alfred Perry, that contains the most startling new revelations about Wigner. The time interval between Fermi's successful operation of an experimental nuclear pile in December 1942 and the completion of the large Hanford reactor for the production of plutonium was less than two years, surely one of the most rapid introductions of a new technology ever. Wigner was at the center of these efforts, and he became deeply involved in the subsequent developments of nuclear engineering, including breeder reactors. Here his training in chemical engineering proved invaluable.

In addition to Wigner's published and unpublished papers on reactor theory and nuclear engineering and an inventory of his patents in the field, volume V contains the memoirs he wrote between 1941 and 1948, in which he chronicled his wartime experiences at the Metallurgical Laboratory in Chicago and later at Oak Ridge National Laboratory. It is a forthright, revealing account of the tensions that existed between the physicists and the engineers at the Met Lab and of the deep strains that attended the design and

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building of the Hanford reactor by the Dupont Co. The memoirs take up over a hundred pages and provide a fascinating new window to the involvement of physicists in the atomic bomb project. This aspect of the story has not been addressed before, and it is told here with candor and passion by one of the principal actors.

Volume VI, which deals with Wigner's philosophical reflections and syntheses, is introduced with a very helpful essay by Gerhard G. Emch. A little over a third of the volume is taken up by essays on the philosophical problems of quantum mechanics, including the measurement problem. Wigner had contributed importantly to the formulation and analysis of the measurement problem that John von Neumann expounded in his *Mathematische Grundlagen der Quantenmechanik* of 1932.

Subsequently, and especially after World War II, Wigner grappled with the conceptual difficulties engendered by the von Neumann formulation of quantum mechanics. He made manifest the restrictions that superselection rules and additive conserved quantities impose on the measurability of Hermitian operators, and he exposed the severe difficulties encountered in a relativistic treatment of measurement. But it was the mystery surrounding the reduction of the wave-packet that elicited Wigner's greatest concern, and he was thus led to speculate about the role of consciousness in describing microscopic phenomena and whether the laws of physics could explain consciousness. To see whether solutions to the reduction problem existed that did not invoke the consciousness of the observer, following a suggestion by Heinz-Dieter Zeh, he explored the implications of the fact that the measuring apparatus must be a macroscopic object and, therefore, that its energy levels are so densely distributed that it can never be considered an isolated system. All these matters are clearly expounded in the essays. Except for John Bell, no one addressed these foundational issues as critically as Wigner did.

Another third of volume VI presents Wigner's essays on symmetries, invariance and conservation laws (including his Nobel Prize lecture). The rest of the volume is made up of writings relevant to the history of nuclear physics and essays the editors have characterized as "philosophically broader." Among the latter are his wonderful essays, "The Limitation of Science" and "The Unreasonable Effectiveness of Mathematics in the Physical Sciences." All of the essays in volume VI are at the level of the curious nonexpert who possesses a minimal command of the quantum mechanical formalism. They are rigorous, lucid and challenging. It would be wonderful if the bulk of the essays in this volume could be made available in an inexpensive paperback edition.

Needless to say, the entire set of Wigner's *Collected Works* should be in every science library. They constitute the legacy of one of the greatest scientists of the present century. We are indebted to Arthur Wightman and his collaborators for making them available.

Health Effects of Exposure to Low-Level Ionizing Radiation

Edited by W. R. Hendee and F. M. Edwards
IOP, Philadelphia, 1996. 568 pp. $250.00 hc ISBN 0-7503-0349-2

Assessments of the health effects of ionizing radiation and the use of these assessments in the framing of public policies remain in a frustrating state. There is a clear and quantifiable connection between cancer induction and radiation exposure at doses above 50 rem (500 millisieverts). But despite intensive investigations—including innumerable epidemiological, animal and cellular studies—it is still not known if ionizing radiation is harmful at the much lower doses encountered in most cases of actual or potential exposure of the public, including the average natural radiation dose of 0.3 rem per year.

Faced with scientific uncertainty, most official and semi-official bodies charged with advising on radiation risks or formulating radiation protection standards have adopted the guideline that the cancer risk is linearly proportional to the dose, down to zero dose—albeit sometimes with a small "dose rate reduction factor" at low doses and low dose rates. At the same time, many scientists believe that the health risks at low doses may be negligible (or zero) and that regulatory agencies have gone too far in erring on the side of caution. For example, the Health Physics Society, a leading US professional organization, earlier this year adopted a controversial policy statement concluding that below 10 rem "risks of health effects are either too small to be observed or are nonexistent."

People interested in understanding what is known and not known about radiation effects will find a valuable resource in the newly published *Health Effects of Exposure to Low-Level Ionizing Radiation*, edited by William Hendee and Marc Edwards. The book presents an extensive overview of the field and the background needed to understand the ongoing controversies, although the focus is more on pedagogy than on controversy. It is aimed at a broad audience of students and professionals, including physicians and physicists, and it does a fine job of meeting the needs of this diverse group.

The book contains 17 chapters, 5 written by the editors and the remainder by highly qualified contributors. With some overlaps, the material falls into four areas: interactions of radiation with matter, results of epidemiological studies, the sources of radiation and the responses of society.

The basic processes involved in radiation damage are described at successive levels, including atoms, cells and laboratory animals. Physicists are likely to find the sections dealing with the interaction of radiation with cells to be especially valuable, even if it is crammed with unfamiliar terminology. If the holy grail in radiation protection is the functional relationship between cancer risk and radiation dose at low doses, then studies of mechanisms at the cellular level may offer the best chance of finding it.

At present, our quantitative knowledge of cancer risks is heavily based on epidemiological studies, most prominently of Hiroshima and Nagasaki atomic-bomb survivors. These and other data are considered in some detail by several authors. In addition, a comprehensive chapter focuses on genetic effects, probably a lesser concern in the absence of statistically significant effects in the Hiroshima–Nagasaki studies.

Other parts of the book provide a detailed picture of the natural, medical and nuclear sources of radiation exposure. Two closing chapters tackle the relationship between public understanding of radiation and the future of such technologies as food irradiation, medical diagnosis and therapy, and, of course, nuclear power. A particularly interesting chapter combines science and good sense in a somewhat stand-alone discussion on the counseling of pregnant women facing diagnostic or therapeutic radiation exposures.

A good index and an extensive glossary would have been valuable in this wide-ranging book; the existing index lacks adequate topic listings and reliable page references, and there is no glossary beyond a summary of radiation dosimetry terms. But an index and glossary do not make or break a book. The present volume has a wealth of important material, presented in a lucid and balanced fashion and (discounting some misprints) at a high level of scientific reliability. If its price is not an obstacle, the book should be