

Percy Williams Bridgman  
and  
the Evolution of Operationalism

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## Abbreviated References

AHQP--Archive for the History of Quantum Physics, Niels Bohr Library, Center for History of Physics, American Institute of Physics, College Park, Maryland.

DPCC--Department of Physics, Correspondence, the Harvard University Archives, Harvard University, Cambridge, Mass., call number: UA V 691.10. Courtesy of the Harvard University Archives.

ECKP--Edwin C. Kemble Papers, the Harvard University Archives, Harvard University, Cambridge, Mass., call number: HUG (FP) 72.10. Courtesy of the Harvard University Archives.

PLDC--Physics Laboratories, Director's Correspondence, Theodore Lyman, 1910-1938, the Harvard University Archives, Harvard University, Cambridge, Mass., call number: UA V 692.5. Courtesy of the Harvard University Archives.

PWBP--Percy Williams Bridgman Papers, the Harvard University Archives, Harvard University, Cambridge, Mass., call number: HUG 4234. xx. Courtesy of the Harvard University Archives.

## Introduction

Werner Heisenberg once mentioned “a strange feeling” he had acquired during his visit to America in 1929: “[W]hile Europeans were generally averse and often overtly hostile to the abstract, nonrepresentational aspects of the new atomic theory, to the wave-corpucle duality and the purely statistical character of natural laws, most American physicists seemed prepared to accept the novel approach without too many reservations.”<sup>1</sup> The attitude Americans took toward theoretical physics was different from that of Europeans, to which Heisenberg was accustomed.

In connection with Americans physicists’ pragmatic approach to philosophical matters, the historian of quantum physics Katherine R. Sopka has pointed out the fact that many young physicists tended to adopt Percy Williams Bridgman’s “operational” point of view in explicating unfamiliar concepts in quantum mechanics.<sup>2</sup> Percy Williams Bridgman (1882-1961) was a Harvard experimental physicist who won the Nobel Prize in Physics in 1946 for his work in high pressure physics, probably better-known as the originator of the view of science called operationalism<sup>3</sup> and as the author of *The Logic of Modern Physics*<sup>4</sup> (1927).

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<sup>1</sup> Werner Heisenberg, *Der Teil und das Ganze: Gespräche im Umkreis der Atomphysik* (München: R. Piper & Co. Verlag, 1969), pp. 132-133 [trans. A. J. Pomerans, *Physics and Beyond: Encounters and Conversations* (New York: Harper and Row, 1971), p. 94].

<sup>2</sup> Katherine Russell Sopka, *Quantum Physics in America 1920-1935* (New York: Arno Press, 1980), p. 3. 68.

<sup>3</sup> The term operationism appeared in the psychological literature in the mid-1930s (see Chapter 6), earlier than physicists and philosophers started to use the word operationalism. However, following physicists and philosopher’s preference, I will use the term “operationalism” when I refer to Bridgman’s and his contemporaries’ various inclinations to define and interpret scientific concepts in terms of operations, except in Chapter 6 where I will mainly discuss psychologists’ operational approach.

<sup>4</sup> P. W. Bridgman, *The Logic of Modern Physics* (New York: Macmillan, 1927).

Not only Sopka but several others have also mentioned the intellectual stimulus Bridgman afforded to younger physicists in the United States. The historian of physics S. S. Schweber has discussed Bridgman's effort to nurture theoretical physics at Harvard and his influence upon the first generation of American quantum physicists, Edwin C. Kemble, John H. Van Vleck, and John C. Slater, depicting the "empiricist temper" of theoretical physicists in the United States.<sup>5</sup> The philosopher of science Nancy Cartwright has found another "wider philosophy" than operationalism among Americans, which, along with Bridgman's operationalism, justified the lack of philosophical anxiety and the reception of quantum mechanics without any metaphysical controversy.<sup>6</sup> One may expect that further analysis of the intellectual interaction between Bridgman and younger quantum physicists will present a notable case in which a physicist's philosophical stance directed the development of scientific activities of one generation.

However, contrary to Sopka, Schweber, and Cartwright, the historian of physics Mara Beller has pointed to the conflict between Bridgman's operational view of science and quantum mechanics and claimed that Bridgman softened his operational requirement because quantum mechanics did not withstand it, although he still tried to criticize this theory from the modified operational standpoint.<sup>7</sup> Furthermore, comparing Bridgman's and Heisenberg's views of the role of operation in scientific theorizing, Beller determined that Bridgman's strict operationalism was inconclusive as an aid for constructing

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<sup>5</sup> S. S. Schweber, "The Empiricist Temper Regnant: Theoretical Physics in the United States 1920-1950," *Historical Studies in the Physical and Biological Sciences*, 17 (1986), pp. 55-98.

<sup>6</sup> Nancy Cartwright, "Philosophical Problems of Quantum Theory: The Response of American Physicists," in Lorenz Krüger and Gerd Gigerenzer, eds., *The Probabilistic Revolution*, 2 vols. (Cambridge, Mass.: MIT Press, 1987), vol. 2, pp. 417-435.

<sup>7</sup> Mara Beller, "Experimental Accuracy, Operationalism, and Limit of Knowledge—1925 to 1935," *Science in Context*, 2 (1988), pp. 147-162.

physical theory. In sum, the historians' analyses of Bridgman's role in the introduction of quantum mechanics into the United States lead one to reason that Bridgman, whose philosophy supposedly provided younger American physicists with a guideline for assimilating quantum mechanics, had in fact difficulty in accepting it.

In a similar manner, one may need to be careful in arguing for Bridgman's influence upon his contemporary psychologists. While Edwin G. Boring has described behaviorists' enthusiasm over Bridgman's operationalism in the 1930s,<sup>8</sup> Sigmund Koch has noticed Bridgman's unsympathetic comments on psychologists' comprehension of operationalism.<sup>9</sup>

A casual look at Bridgman's writings would reveal some fluctuation in the evolution of his views. For instance, while in *The Logic of Modern Physics* Bridgman expected that quantum mechanics would present an ideal way of theorizing in physics, two years later he published his pessimistic interpretation of this theory whose extremity even bewildered his colleagues at Harvard.<sup>10</sup> For further understanding of the cause for such fluctuation, one needs to analyze the evolution of Bridgman's ideas with aid of survey of his personal documents.

Historians have considered Bridgman's reflections on science as a comprehensive, though not very systematic, criticism of the foundations of modern physics, of the kind infrequently published by professional experimental physicists in the twentieth century, especially in the United States: Maila L. Walter has illustrated his life as a tragedy of a

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<sup>8</sup> Edwin G. Boring, *A History of Experimental Psychology*, 2<sup>nd</sup> ed. (New York: Appleton-Century-Crofts, Inc., 1950), pp. 653-659.

<sup>9</sup> Sigmund Koch, "The 'Operational Principle' in Psychology: A Case Study in Cognitive Pathology" (Paper presented at the symposium "Reflections on P. W. Bridgman: A Centenary Symposium," Boston University, Apr. 24, 1982).

<sup>10</sup> P. W. Bridgman, "The New Vision of Science," *Harper's Magazine*, 158 (1929), pp.

physicist who was trained in the tradition of classical experimental physics and New England Protestantism (though he remained an atheist throughout his life), tried to comprehend the new wave of modern physics in his own language, failed, and died in despair;<sup>11</sup> Albert E. Moyer has painstakingly followed the development of Bridgman's thought until the publication of *The Logic of Modern Physics*;<sup>12</sup> and Stanley Goldberg has analyzed Bridgman's understanding of relativity theory and suggested the difference between "operationalism and being operational."<sup>13</sup> Among them, only Walter has pointed to the discrepancy between Bridgman's original stance and his psychological and philosophical contemporaries' understanding of operationalism, but no one seems to have successfully described what caused it.

In this present thesis I will attempt to clarify Bridgman's views of science by tracing the formation and transformation of his operational perspective and evaluating his influence upon his contemporary scientists, in order to explicate the limitations and the basic assumptions, both explicit and implicit, of operationalism. More specifically, I will try to answer the question of why Bridgman remained critical to quantum mechanics while his contemporary physicists invoked his operational stance in assimilating this physical theory. For this purpose, I will discuss the following issues: Bridgman's educational background and experimental work (Chapter 1); his various efforts for the establishment of theoretical research at Harvard (Chapter 2); his

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443-451.

<sup>11</sup> Maila L. Walter, *Science and Cultural Crisis: An Intellectual Biography of Percy Williams Bridgman (1882-1961)* (Stanford: Stanford University Press, 1990).

<sup>12</sup> Albert E. Moyer, "P. W. Bridgman's Operational Perspective on Physics, Part I: Origins and Development," *Studies in History and Philosophy of Science*, 22 (1991), pp. 237-258; "Part II: Refinements, Publication, and Reception," *Studies in History and Philosophy of Science*, 22 (1991), pp. 373-397.

<sup>13</sup> Stanley Goldberg, "Being Operational vs. Operationalism: Bridgman on Relativity,"



argument of dimensional analysis (Chapter 3); the formation of operational perspective under the influence of relativity theory (Chapter 4); his analysis of the conceptual framework of quantum mechanics as compared with younger quantum physicists' views of philosophical matters in physics (Chapter 5); the discussions of the operational method among American psychologists in the 1930s (Chapter 6); and his operational analysis of social issues that revealed his views of the social status and responsibility of science (Chapter 7). This thesis, which will proceed roughly chronologically, aims to answer the following questions: how and why Bridgman developed his operational perspective on science; what caused the transformation in his philosophical stance; and how his contemporaries, especially physicists and psychologists, reacted to his operational method.

Bridgman's correspondence, manuscripts, and notebooks are kept at the Harvard University Archives (Percy Williams Bridgman Papers) in more than a hundred small boxes. Though Bridgman destroyed much of his correspondence before he died, Bridgman Papers, one of the most frequently requested collections at the Harvard University Archives, have remained to be the richest source of information of his intellectual activities. The works of Walter, Schweber, Goldberg, and Moyer have been based on their surveys of Bridgman Papers. I began my research for this dissertation by examining all the documents in Bridgman Papers. In order to find the information of Bridgman's educational background, his teaching, and his position at the department, I surveyed the correspondences of the directors of the Physics Laboratory and the Department of Physics at Harvard, as well as Edwin C. Kemble's personal documents (Edwin C. Kemble Papers), which are also housed at the Harvard University Archives.

Because of the limitations imposed by the purpose of this present thesis, I will not be able to discuss many interesting points related to Bridgman. As for the following topics, I will only take up limited aspects necessary for the purpose of this thesis: The biographical details of Bridgman; the reception of relativity theory and quantum theory in the United States as a whole; and the activities of the Harvard Physics Department. When necessary, I will refer the reader to the works, including the ones I have already mentioned, which will give sufficient knowledge about these points.