

**JULIA HARRIET MENZEL AND DAVID KAISER\***

## **Weimar, Cold War, and Historical Explanation: Re-reading Forman**

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### **ABSTRACT**

This essay is part of a special issue entitled “Looking Backward, Looking Forward: *HSNS* at 50,” edited by Erika Lorraine Milam.

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When historians of science try to make sense of the dramatic sweep of physics over the course of the twentieth century, two episodes often stand out: the intellectual ferment during the first quarter of the century, from which emerged both relativity and quantum theory; and the massive enrollment of physicists in military projects during and after the Second World War. Grappling with each of these transformations historically has elicited methodological challenges as much as empirical ones—challenges regarding agency, structure, and scale. Two of the most momentous interventions in this long-running scholarly discussion were written by Paul Forman and published in this journal: his early study of quantum physicists’ embrace of acausality during the years right after the First World War, and his later study of physicists and military patrons during the early Cold War. As we argue here, these articles point with fresh urgency to still-unresolved methodological challenges, well beyond the debates that had shaped their initial reception.

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The following abbreviation is used: *HSPS*, *Historical Studies in the Physical Sciences* and *Historical Studies in the Physical and Biological Sciences*.

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*Historical Studies in the Natural Sciences*, Vol. 50, Number 1-2, pps. 31-40. ISSN 1939-1811, electronic ISSN 1939-182X. © 2020 by the Regents of the University of California. All rights reserved. Please direct all requests for permission to photocopy or reproduce article content through the University of California Press’s Reprints and Permissions web page, <https://www.ucpress.edu/journals/reprints-permissions>. DOI: <https://doi.org/10.1525/hsns.2020.50.1-2.31>.

**“WEIMAR CULTURE”**

Published in 1971, Paul Forman’s “Weimar culture, causality, and quantum theory” spurred a reimagining of the nature of explanation within the history of science.<sup>1</sup> In the piece, Forman focused on the early generation of quantum physicists, based largely in Germany in the immediate aftermath of the First World War. He argued that many of these physicists seized upon probabilistic and seemingly acausal features of the emerging quantum formalism well before robust scientific evidence had compelled them to do so. Neither stubborn data nor compelling theories could account for the timing; rather, according to Forman, the physicists embraced acausality to appease a “hostile environment,” exemplified by Oswald Spengler’s widespread declarations that the recent slaughter, and Germany’s shocking defeat, had demonstrated that nature itself was not bound by once-canonical rules of cause and effect.

“Weimar culture” grew out of Forman’s 1967 dissertation, which he completed at Berkeley under Thomas Kuhn’s direction. His thesis, in turn, was likely the very first to draw upon the ambitious and sprawling Archive for History of Quantum Physics project, which had been directed by Kuhn and on which Forman had served as a young assistant during the early 1960s.<sup>2</sup> “Weimar culture” was not Forman’s first professional publication in the history of science; he had already published significant articles on quantum theorists’ responses to curiosities of atomic spectra and early steps toward wave mechanics.<sup>3</sup> But among his early articles, “Weimar culture”—which filled 115 journal pages—was his most ambitious.

With hindsight, it is difficult not to read the article either as a forerunner of social histories to come, or as the product of the long-running debate over

1. Paul Forman, “Weimar culture, causality, and quantum theory, 1918–1927: Adaptation by German physicists and mathematicians to a hostile intellectual environment,” *HSPS* 3 (1971): 1–115.

2. Paul Forman, *The Environment and Practice of Atomic Physics in Weimar Germany: A Study in the History of Science* (PhD dissertation, University of California at Berkeley, 1967); John L. Heilbron, “Quantum historiography and the Archive for History of Quantum Physics,” *History of Science* 7 (1968): 90–111; Anke te Heesen, “Thomas Kuhn, ear witness: Fieldwork and the making of a new history of science” (Distinguished Lecture, History of Science Society annual meeting, Utrecht, The Netherlands, Jul 2019).

3. Paul Forman, “The doublet riddle and atomic physics circa 1924,” *Isis* 59 (1968): 156–74; V. V. Raman and Paul Forman, “Why was it Schrödinger who developed de Broglie’s ideas?,” *HSPS* 1 (1969): 291–314; Forman, “Alfred Landé and the anomalous Zeeman effect, 1919–1921,” *HSPS* 2 (1970): 153–261.

“internalist” and “externalist” approaches to the history of science that dominated the period. Forman’s article was wielded for diverse purposes in the lively methodological debates of the 1970s and 1980s, and critics and advocates alike imposed influential readings on the text.<sup>4</sup> Edinburgh sociologist Barry Barnes, for example, marveled at Forman’s story, taking it as proof of concept for an ambitious macrosociological method.<sup>5</sup> David Bloor, too, read his own model of social imagery back into Forman’s “fascinating and controversial study of the physicists of Weimar Germany,” identifying Forman as a formidable sociologist of scientific knowledge *avant la lettre*.<sup>6</sup>

Rather than reading “Weimar culture” as an exemplary externalist history, however, we are interested in the insights that this classic study holds for historians of science today. Despite the uses that others made of the piece throughout the internalism-externalism debate, the article was among the earliest to be published in the new journal *Historical Studies in the Physical Sciences*, whose editor Russell McCormmach explicitly solicited contributions that sought to “challenge the cogency of the currently held view of the internalist-externalist distinction” and advance “the synthesis of the intellectual and social history of science” that he hoped would replace it.<sup>7</sup> Forman had likewise announced in the opening pages of his dissertation that he had “not introduced a distinction between ‘internal’ and ‘external’ factors and influences,” since in too many instances of interest, it remained “impossible to say where to draw the line.”<sup>8</sup>

Instead, Forman emphasized *institutions* as a special locus within which a large range of factors converged. In his dissertation, he noted that his “principal aim is to give some life and character to the various institutions—e.g., academic positions, physical journals, the concept of priority,” which had often animated previous historical accounts, alongside “economic conditions, political attitudes, personal grudges, public and governmental attitudes toward science, sources of research funds,” which typically made “no appearance at all in histories of scientific advance.”<sup>9</sup>

4. Cathryn Carson, Alexei Kojevnikov, and Helmuth Trischler, eds., *Weimar Culture and Quantum Mechanics: Selected Papers by Paul Forman and Contemporary Perspectives on the Forman Thesis* (Singapore: World Scientific, 2010).

5. Barry Barnes, *Scientific Knowledge and Sociological Theory* (London and Boston: Routledge and Kegan Paul, 1974), 109–10.

6. David Bloor, *Knowledge and Social Imagery* (London: University of Chicago Press, 1976), 7.

7. Quoted in Steven Shapin, “Discipline and Bounding: The History and Sociology of Science as Seen through the Externalism-Internalism Debate,” *History of Science* 30, no. 4 (1992): 344.

8. Forman, *Environment and Practice* (ref. 2), iv.

9. *Ibid.*, iii–iv.

Like his dissertation, Forman's account in "Weimar culture" has an institutional structure to it, local gears that could mesh and turn and thereby drive the argument. The "hostile environment" about which he wrote had been made manifest for physicists not through some fog of a discursive field dotted with *Lebensphilosophische* slogans, but in specific institutional settings, such as the *Reden*, formal inaugural lectures required of new faculty within the German university system. Standing at a podium, staring out at the stern faces of the Mandarin class—those esteemed philologists, philosophers, and other humanists who filled the leadership positions throughout German universities—ambitious young scholars like Werner Heisenberg (son of a classicist) adapted their message to align with what their university superiors expected to hear.<sup>10</sup> The reign of causality had ended, they now proudly declared; even the secrets of the atom bespoke randomness, probabilities, and the fall of determinism. Little wonder, then, that Heisenberg first published an account of his now iconic uncertainty principle of 1927 in a popular science magazine, before a more formal account had appeared within the *Zeitschrift für Physik*.<sup>11</sup>

In this way, Forman's controversial study invoked a "sociological" explanation only to carefully circumscribe its domain of application. "The 'sociological' mode employed in this paper cannot be the whole truth," he emphasized in the article's conclusion. "It provides a general framework," but one whose "special applicability" appears limited to "certain extreme cases."<sup>12</sup> "Weimar culture" provides a close analysis of a specific and unusual historical episode, rather than a case study meant to prove a general theoretical point about science and society.

What makes Forman's case "extreme"? One striking aspect is the pronounced *isolation* of Forman's university physicists from broader Weimar culture. Since the article's publication, it has become a matter of principle within the history of science to insist always on the embeddedness of science in society—and there can be no doubt that even the abstruse concepts of quantum physics are worldly things produced by particular people in specific cultural contexts, toward interested ends. Yet revisiting Forman's article makes

10. Forman, "Weimar culture" (ref. 1), 9. See also Fritz Ringer, *The Decline of the German Mandarins: The German Academic Community, 1890–1933* (Cambridge, MA: Harvard University Press, 1969).

11. Forman, "Weimar culture" (ref. 1), 104–06; see also David Cassidy, *Uncertainty: The Life and Science of Werner Heisenberg* (San Francisco: W. H. Freeman, 1992), chap. 12; and Cathryn Carson, *Heisenberg in the Atomic Age: Science in the Public Sphere* (New York: Cambridge University Press, 2010), chaps. 3–4.

12. Forman, "Weimar culture" (ref. 1), 114.

clear that the degree to which scientists are functionally integrated into society is a matter of historical inquiry, not philosophical precept. Aloofness, distance, and illegibility—just as much as imagined forms of full immersion—each describe ways of taking up a position within a social world.

Throughout “Weimar culture,” Forman characterizes the relative isolation of physicists not as a transhistorical fact, but rather as a contingent state of affairs that had become a *problem* for the exact scientists. Immediately after the war, they found themselves in a position of weakness: enrollments were declining; new reforms from the Prussian Ministry of Education posed an imminent “threat,” based as they were upon a widespread understanding of the exact sciences as inhuman and destructive. Backed into a corner, the typical quantum physicist—young and ambitious, but not yet in a position of authority within his own institution—needed to reimagine how to make “contact with his audience” by demonstrating, somehow, that “he himself is ‘with it,’ sharing the spirit of the times.”<sup>13</sup> The apparent separation of science and society, then, was the consequence of a profound political failure by scientists to secure a place for themselves in their world.

This frames Forman’s concern for justification: physicists’ attempts to explain their work and convince diverse audiences of its value by appealing to general principles. He documents a shift from “utilitarian justifications of the pursuit of science,” which had emphasized the value of physics in terms of what it offers technology and industry, to a discourse of high “culture,” which appealed to the artistic and humanistic value of scientific inquiry.<sup>14</sup> Forman demonstrates how Willy Wien, for example, confidently cited the strong connection between physics research and German industry in 1918, only to “totally [abstain] from any attempt to justify science by utility” in 1925, by which point he had learned instead to claim that “the goal of science is culture.”<sup>15</sup> Forman ties this discursive transformation to the growing belief, among education ministry officials as well as others, that “the economic-political, technical, and positivistic age” had given way to a new era, combined with a skepticism toward the fruits of the second industrial revolution. This shift from utilitarian to humanistic frameworks of justification went beyond a mere change in rhetorical tune; it entailed a transformation in how physicists were socialized as certain kinds of public actors,

13. *Ibid.*, 58.

14. *Ibid.*, 7.

15. *Ibid.*, 44. See also Suman Seth, *Crafting the Quantum: Arnold Sommerfeld and the Practice of Theory, 1890–1926* (Cambridge, MA: MIT Press, 2010), chap. 3.

the incentives they could mobilize to recruit and motivate students, and the terms on which they received funding from the Prussian state.

### “BEHIND QUANTUM ELECTRONICS”

How different those terms of justification had become for the physicists on whom Forman focused in his second landmark article, “Behind quantum electronics: National security as basis for physical research in the United States, 1940–1960.”<sup>16</sup> Here again Forman’s analysis is animated by questions of coercion and scientists’ adaptation—even capitulation—to an unusual environment, this time during times of plenty rather than want. Though merely 81 journal pages long (rather than 115), “Behind quantum electronics” had a comparable impact on generations of historians grappling with questions of scientists and the state.

Like his study of Weimar physicists, Forman’s deep analysis of physicists in the United States during the middle decades of the twentieth century took shape as a series of related articles.<sup>17</sup> Forman composed this series while ensconced in Washington, D.C., as a curator at the National Museum of American History. A new torrent of spending by the Reagan Administration in the 1980s on high-tech defense systems focused Forman’s attention on the vast transformations in the scale and scope of physicists’ work in the United States that had begun during the Second World War. The urgency to understand historical connections between the present in which Forman was writing and the recent past seemed all too clear:

Not the Strategic Defense Initiative alone, but the pattern of priorities in America of the 1980s, within which ‘Star Wars’ fits so naturally, thrusts our

16. Paul Forman, “Behind quantum electronics: National security as basis for physical research in the United States, 1940–1960,” *HSPS* 18, no. 1 (1987): 149–229.

17. Paul Forman, “Atomichron (R): The atomic clock from concept to commercial product,” *Proceedings of the IEEE* 73 (1985): 1181–1204; Forman, “Social niche and self-image of the American physicist,” in *The Restructuring of Physical Sciences in Europe and the United States, 1945–60*, ed. M. de Maria, M. Grilli, and F. Sebastiani (Singapore: World Scientific, 1989), 96–104; Forman, “Inventing the maser in postwar America,” *Osiris* 7 (1992): 105–34; Forman, “‘Swords into ploughshares’: Breaking new ground with radar hardware and technique in physical research after World War II,” *Reviews of Modern Physics* 67 (1995): 397–455; Forman, “Into quantum electronics: The maser as ‘gadget’ of Cold War America,” in *National Military Establishments and the Advancement of Science and Technology*, ed. P. Forman and J. M. Sanchez-Ron (Dordrecht: Kluwer, 1996), 261–326.

attention toward the national security contexts of quantum electronics. . . . My thesis is that here American physics, accelerating in historic quantitative growth, underwent a qualitative change in its purposes and character, an enlistment and integration of the bulk of its practitioners and its practice in the nation's pursuit of security through ever more advanced military technologies.<sup>18</sup>

“Behind quantum electronics” makes for interesting reading in light of contemporary discussions of “scale” in the history of science.<sup>19</sup> If scholars have come to see the mid-1980s as a key inflection point in the field's trajectory, at which “miniaturizing tendencies” came to displace “macrosocial explanations,” then Forman's essay stands out as an exception to this trend.<sup>20</sup> Whereas “Weimar culture” focused on the experiences of a handful of physicists, fitting securely within the conventions of cultural history, “Behind quantum electronics” makes its arguments with tables of quantitative data, time-series plots, and long paragraphs thick with percentages and dollar-values. To some extent, this reflects a difference of subject matter—“big science” certainly lends itself to economic and scientometric analysis—but it is nonetheless striking to revisit, whatever one thinks of the localism of much recent work in science studies. We cannot help but marvel at Forman's ambition in “Behind quantum electronics,” which seeks to characterize several decades of momentous transformation—a “watershed” moment, if ever there was one—within the confines of a standalone article.

18. Forman, “Behind quantum electronics” (ref. 16), 149–50. On physicists' fraught relationships with the Reagan-era Strategic Defense Initiative, see Peter Westwick, “The international history of the Strategic Defense Initiative: American influence and economic competition in the late Cold War,” *Centaurus* 52, no. 4 (2010): 338–351; Rebecca Slayton, *Arguments that Count: Physics, Computing, and Missile Defense, 1949–2012* (Cambridge, MA: MIT Press, 2013), chap. 8; Benjamin Wilson, *Insiders and Outsiders: Nuclear Arms Control Experts in Cold War America* (PhD dissertation, Massachusetts Institute of Technology, 2014), chap. 5; and Sarah Bridger, *Scientists at War: The Ethics of Cold War Weapons Research* (Cambridge, MA: Harvard University Press, 2015), chap. 9.

19. Cf. Lorraine Daston and Peter Galison, *Objectivity* (New York: Zone Books, 2007); Robert E. Kohler and Kathryn M. Olesko, eds., *Clio Meets Science: The Challenges of History*, published in *Osiris* 27, no. 1 (2012): 1–350; Deborah R. Coen, *Climate in Motion: Science, Empire, and the Problem of Scale* (Chicago: University of Chicago Press, 2018).

20. For “miniaturizing tendencies,” see Lorraine Daston, “Science studies and the history of science,” *Critical Inquiry* 35, no. 4 (2009): 809. For “macrosociological explanations,” see Jan Golinski, *Making Natural Knowledge: Constructivism and the History of Science* (New York: Cambridge University Press, 1998), 10.

Forman's choice of scale in "Behind quantum electronics" is closely related to the most controversial claim of the essay. In the closing pages of the long article, the charts, graphs, and tables give way to a different register. Forman briskly replaces the quantitative idiom with a language of morality, concluding that Cold War physicists in the United States had fallen prey to their own "false consciousness":

On the one hand they focused so narrowly on immediate cognitive goals of their work as to miss its instrumental significance (and financial insignificance) to their military patrons. On the other hand they pretended a fundamental character to their work that it scarcely had. . . . Though they have maintained the illusion of autonomy with pertinacity, the physicists had lost control of their discipline.<sup>21</sup>

In Forman's telling, the Cold War physicists had capitulated—just as surely as their long-distant Weimar cousins had done—to an unusual institutional nexus that had exploited their technical talents and distorted their intellectual efforts toward military ends, even as they had "blinded themselves" to the stark extent of their co-optation.<sup>22</sup>

Forman's "distortionist" thesis quickly inspired reactions among historians eager to make sense of the enormous growth of the scientific enterprise within Cold War America. Some, like Daniel Kevles, countered that terms such as "pure" and "applied," "basic" and "mission-oriented" research had themselves been moving targets throughout history, and that researchers have always needed to navigate complicated relationships with patrons.<sup>23</sup> Others responded that one need not imagine some bygone era of purity in order to assess the new possibilities—even sensibilities—set in motion by the saturation-level funding of the physical sciences by federal defense agencies after the war, which Forman had pulled so sharply into focus. As particle physicists and their hulking cryogenics equipment rotated between hydrogen-bomb tests in the South Pacific and bubble-chamber experiments at Berkeley's Radiation Laboratory, or oceanographers maneuvered between anti-submarine research and investigations of sea-floor spreading—all while aboard naval vessels—the intellectual and infrastructural entanglements

21. Forman, "Behind quantum electronics" (ref. 16), 228–29.

22. Forman, "Behind quantum electronics" (ref. 16), 228.

23. Daniel Kevles, "Cold War and hot physics: Science, security, and the American state, 1945–56," *HSPS* 20, no. 2 (1990): 239–64.



between physical sciences and the military became new facts of life for researchers in the United States.<sup>24</sup>

What these lively discussions point to, we suggest, is the difficulty of meshing multiple scales of analysis. If Forman's focus on the structures that restrict human agency led him to discount scientists' perspectives altogether in "Behind quantum electronics," then many of his critics have perhaps overvalued physicists' own sense of reality and autonomy. Arguably, Forman's accusation of "false consciousness" is so jarring to us as contemporary readers exactly because the contrasting preference for individual "agency" over social "structure" was codified in many of the critical approaches that came to predominate in the history of science, ranging from the turn to practice in the 1990s to more recent concerns with materiality.<sup>25</sup>

Forman's arresting conclusion in "Behind quantum electronics" therefore points to a theoretical question that is still very much with us, raised anew by recent calls for multiple scales of historical analysis. This is what feminist theorist Lauren Berlant calls the "lack of fit between conventions of structural determination and subjectivity": how do we account for scientists' subjective experiences, neither dismissing nor affirming them, while also attending to structural forces that condition them, which are by definition transpersonal and gradual?<sup>26</sup> Rather than pitting "macro" or "micro" scales of analysis against one another, this would require us to learn how to reconcile them.

24. Peter Galison, *Image and Logic: A Material Culture of Microphysics* (Chicago: University of Chicago Press, 1997), chap. 5; Naomi Oreskes, "A context of motivation: US Navy oceanographic research and the discovery of sea-floor hydrothermal vents," *Social Studies of Science* 33, no. 5 (2003): 697–742. See also Stuart W. Leslie, *The Cold War and American Science* (New York: Columbia University Press, 1992); David Kaiser, "Cold war requisitions, scientific manpower, and the production of American physicists after World War II," *HSPS* 33, no. 1 (2002): 131–59; Benjamin Wilson and David Kaiser, "Calculating times: Radar, ballistic missiles, and Einstein's relativity," in *Science and Technology in the Global Cold War*, ed. Naomi Oreskes and John Krige (Cambridge, MA: MIT Press, 2014), 273–316; Benjamin Wilson, "The consultants: Nonlinear optics and the social world of Cold War science," *Historical Studies in the Natural Sciences* 45, no. 5 (2015): 758–804. For an insightful review, see Cyrus Mody, "How I learned to stop worrying and love the bomb, the nuclear reactor, the computer, ham radio, and recombinant DNA," *Historical Studies in the Natural Sciences* 38, no. 3 (2008): 451–61.

25. In a recent assessment, Lorraine Daston submits that "Most historians of science no longer believe that *any* kind of structure could possibly do justice to their subject matter." Lorraine Daston, "History of science without *Structure*," in *Kuhn's Structure of Scientific Revolutions at Fifty: Reflections on a Science Classic*, ed. Robert J. Richards and Lorraine Daston (Chicago: University of Chicago Press, 2016), 117.

26. Lauren Berlant, *The Female Complaint: The Unfinished Business of Sentimentality in American Culture* (Durham, NC: Duke University Press, 2008), 254.

## CONCLUDING THOUGHTS

In the end, Forman's own efforts to articulate accounts that were both local and structural remained ambivalent. On the one hand, his discussion of justification in "Weimar culture" retains radical potential. Taken to its logical conclusion, "Weimar culture" can be read as an argument about subject formation: the quantum physicists at the center of that account do not stand outside of history as rational social atoms; rather, they must always interpret themselves and their interests in received terms that both constitute and constrain their agency. Little wonder the article held such appeal to early advocates of macrosocial explanations, who saw in his work evidence that institutions shape scientists, within which scientists pursue research in particular ways that become self-reinforcing within those same institutional forms. Yet Forman himself shied away from such a strong version of his claim by the close of the article, electing instead to invoke individualist notions of "personality and intellectual biography" that implicitly grounded his moral critique.<sup>27</sup>

In much the same way, "Behind quantum electronics" does so much to reveal the pervasive conditions and constraints under which Cold War scientists labored within the United States. In the closing pages of his long and compelling analysis, however, Forman again switches gears. The conclusions he draws seem to make sense only if one assumes the existence of some neutral ground, innocent of the conditioning effects of politically enmeshed institutions. After so carefully attending to forms of indirect coercion that nudge scientists' actions in line with power, securing their willing assent to their own exploitation, Forman reverses course by suggesting that Cold War physicists had wittingly sold out. Nevertheless, whether or not one follows Forman for the final finger-wagging, our understanding of the immense shift in the institutional emplacement of physics and physicists at midcentury will never be the same.

Re-reading Forman's classic articles today, we admire anew the exhaustive and wide-ranging empirical sources on which each piece drew and the profound methodological stakes that drove each daring intervention. No matter how the field continues to refine and revisit our understanding of the history of modern physics, one thing is clear: our interpretations have been indelibly shaped by these remarkable articles.

27. Forman, "Weimar culture" (ref. 1), 114.