Conference: The Cultural Alchemy of the Exact Sciences: Revisiting the Forman Thesis, March 2007

Paul Forman's article "Weimar Culture, Causality, and Quantum Theory, 1918-1927" (Forman 1971) permanently changed the disciplinary landscape of the history and philosophy of science. Commonly called the Forman thesis, it profoundly affected the work of a generation of historians and philosophers of physics. As a classic essay in the "externalist" history of science (so the paper is usually read), it contributed just as significantly to the appeal of the new sociology of scientific knowledge. It helped define the cultural history of science that spread through the field in the 1980s and 1990s, and it has been a touchstone for general historians of Germany and continental Europe seeking contact with science.

Although one of the most frequently cited works in the field, the Forman thesis nevertheless cannot be considered universally accepted. On the contrary, it remains as controversial as it is famous, the subject of polarized opinions and scholarly positions. Indeed, its contested nature is responsible for its ongoing influence, as it continues to spark methodological discussion and inspire new empirical studies. The current state of that debate, including some exciting recent contributions of younger scholars, leads us to propose our conference as a venue where different lines of research and reflection can be brought into productive exchange. Its tangible products will be two cohesive collections of conference papers, in both English and German, to serve the discipline at large.

Forman's study surveyed the cultural milieu and social standing of physical and mathematical sciences in Germany during the first years of the Weimar Republic, immediately following the nation's defeat in World War I and the collapse of the old Imperial regime. The 2

postwar national crisis – social, economic, cultural, and intellectual at once – helped stir up a general hostility of the educated German elite towards ideas of progress, rationality, modernity, materialism, and determinism. This cultural climate affected the generation of physicists and mathematicians who subsequently played the leading role in a great scientific breakthrough, the creation of quantum mechanics. In particular, as one of his boldest claims, Forman argued that a key feature of the new quantum theory – its indeterministic, acausal laws governing the behavior of electrons and other subatomic particles – came as a result of a deliberate adaptation of exact scientists to hostile cultural surroundings, as a way of improving their own social standing. In the process they abandoned some of the long-cherished ideals of the scientific enterprise, such as causality, in favor of more irrationalist lines of thought. These culturally laden ideas became part and parcel of the conventional understanding of the quantum theory, known as the Copenhagen interpretation.

Forman's 1971 study is arguably – with the possible exception of Boris Hessen's "Social and Economic Roots of Newton's Principia" – the most influential single journal article ever published in the history and philosophy of science. One of the most frequently cited papers in the field's literature, it has a long and consistent career, as the Social Science Citation Index confirms. Thirty-five years after its appearance, "Weimar Culture" remains a classic, while never ceasing to be controversial. It continues to provoke new scholarship – supporting as well as oppositional – and to influence new research. These fields in which its impact has been most felt can be grouped into four categories. 3

1. The historiography of modern physics.

Professional historiography of the quantum revolution was just emerging when the Forman thesis was being forged (cf. Forman 1967). The field was shaped at its inception by Kuhn, J.L. Heilbron, and Forman himself (Kuhn 1978, Heilbron and Kuhn 1969, Forman, Heilbron, and Weart 1975) and by the creation of the monumental Archive for History of Quantum Physics (AHQP) (Kuhn et al. 1967). Forman's article, appearing at a crucial moment, helped set the terms for the discussion, providing critical impulses to key papers (e.g., Brush 1980, Heilbron 1985) and fodder for scholarly controversy (Hendry 1980, Kraft and Kroes 1984). It has continued to exercise influence as obligatory reading for students and scholars working on the history of quantum mechanics (von Meyenn 1994, cf. Sanchez-Ron 1984).

Since then, the burgeoning field, coming into its own, has produced highly detailed empirical studies of many aspects of the story, including its technical formalism (Darrigol 1992, Mehra and Rechenberg 1982ff, and dozens of individual articles), its philosophical background (Beller 1983, 1985, 1988, 1990, Hendry 1984, Wise 1987), and its political and institutional settings (Forman 1973, 1974, Robertson 1979, Eckert 1993, Kirchhoff 2003). It has been enriched by thorough biographies of major participants (Heilbron 1986, Dresden 1987, Cassidy 1992, Enz 2002) and editions of their correspondence (Pauli 1979ff). It has also been stretched by recent scholarship pressing some of its suggestions on the cultural environment of physics, exploring other figures or pushing its questions back to the pre-Weimar period (Wise 1994, Beyler 1994, Stölzner 2001, Schirrmacher 2001, 2002, Wolff 2003, Seth 2003, Carson 2003, Coen 2004, Jurkowitz 2005, Staley 2005). The much broader empirical basis made available by 4

these studies makes it possible to revisit Forman's original ideas, drawn from a particular set of sources, and to assess in what respects they should be sustained, disproved, or revised.

2. Cultural and political contexts of science in comparative perspective.

Forman's article has been no less transformative for cultural and political studies of early twentieth-century science. For the history of science in Weimar Germany, the essay has been a foundational text, as the cultural milieu operative for Forman's physicists has been generalized to cases beyond the exact sciences. This can be seen not just in the universality of direct citations to "Weimar Culture" (even beyond specialist historians of science – e.g., Schiemann 1996), but in the pattern of reference to specific works of German history it made central to the cultural contextualization of science (Ringer 1969, Stern 1961, Mosse 1964). So even when historians do not accept Forman's thesis in its radical formulation, they have generally relied and built upon his depiction of the atmosphere and setting of the scientific enterprise in Germany of the 1920s, and similar ideological and political issues have since been highlighted in studies of other scientific disciplines, such as biology and psychology (Harwood 1993, 1996, Ash 1995, Beyler 1996, Harrington 1996, Hopwood 1997, Hessenbruch 2000, Timmerman 2001). Forman's ideas have been tested for utility, further, in a larger chronological frame of German history outside the Weimar period per se, either in the preceding Kaiserreich, where its reception has been more ambivalent, or in the following Third Reich and the post-WWII era, where its diagnosis of scientific accommodation to political and cultural reaction has been extremely influential (McCormmach 1982, Nyhart 1998, Daum 1998; Beyerchen 1977, Beyerchen 1992, Fischer 2000, Beyler 2003). Its ongoing relevance is conspicuous in the newly emerging attempts at 5

synthetic accounts, especially those volumes that have reached out to German cultural and political history more broadly (Metzler 2000, vom Bruch and Kaderas 2002, Trischler and Walker forthcoming). Yet this field, too, has been enormously enriched by detailed empirical studies, and these call out for more than easy synthesis. At the same time, the larger historical literature on German modernity has shifted direction away from the sources on which Forman relied. These circumstances invite a new look at the Forman thesis as an account of Weimar science.

Large problems remain, too, in cross-cultural comparisons. Although primarily a German invention, quantum mechanics almost immediately spread internationally, to countries and cultures with very different political and ideological values and climates. Already the closely related case of Denmark, where many of the authors of quantum mechanics worked, creates some difficulties for the Forman thesis. Authors studying the reception of quantum physics in other countries, such as Great Britain, France, United States, the Soviet Union, or Japan, have often found Forman's ideas heuristically important and illuminating, but more often by the way of contrast rather than by direct applicability to other contexts (Ringer 1986, Pestre 1984, Nye 1997, Schweber 1986, Cartwright 1988, Vucinich 1980, Cross 1991, Kojevnikov 1999, Hall 1999, Ito 2002). The question how much of the original ideological and cultural baggage was carried along in the theory's global reception, and how much of it is changed on the way, requires further investigation. This double move, to revisit the transnational spread of science at the same time as its local contextualization, can be carried out for no example so thoroughly as for Forman's case of quantum mechanics. 6

3. Philosophical interpretation.

Attitudes towards the philosophical interpretation of the quantum theory have likewise undergone dramatic changes since the Forman thesis was published. In the early 1970s, the Copenhagen interpretation was dominant and the acausal vision of quantum laws was almost universally recognized as belonging to the core formalism of the theory. Thanks largely to the works by David Bohm and John Bell – the latter actually cited Forman's thesis in one of his papers (Bell 1982) – physicists' views have changed in the direction of philosophical pluralism, within which different interpretations of quantum theory, from causal and deterministic alternatives to the more outré "many-world interpretation," are considered possible. Philosophers of science, such as Mara Beller (1999) and James Cushing (1994), have argued that some important aspects of the Copenhagen interpretation were historically contingent, thereby accepting the possibility of cultural influence, albeit principally on developments they consider misguided. Some of Forman's own work (particularly Forman 1984) has similar overtones. The topic is manifestly one that can engage historians and philosophers in productive dialogue.

4. Sociological approaches.

Without this necessarily having been the author's intent, the Forman thesis played an important role in the spread of the sociology of scientific knowledge in the 1980s. Many of the pioneers of the new sociological approach referred to the case of quantum acausality as the single most powerful demonstration of the far-reaching influence of social factors on the hard theoretical core of scientific knowledge (Bloor 1981, Collins 1981, Shapin 1992). Despite decades of research and the wide acceptance and many applications of sociological approaches 7

in contemporary science studies, the Forman thesis remains the most thoroughly investigated test case for such claims. It is also one of the most significant theoretically, since physics and the exact sciences are still typically considered a harder target than the life and human sciences.

In the broader social and cultural history of science, into which the sociology of scientific knowledge has partly been folded, a vast range of new methodologies have been advanced since "Weimar culture." The mechanisms of societal shaping of science, as Forman presumed them to operate, have been expanded and rethought. In particular, the strongly causal models of influence and interest characteristic of the early years of the sociological program have been supplemented by (or watered down to) more causally modest accounts of resources and resonances. Even as Forman's analysis has been cited, his explanatory scheme has been scrutinized and modified (Wise unpublished). The Forman thesis remains an exemplary site for reflections on the shifting role of sociological approaches and other changes underway in the methodology in science studies. 8

References Cited

Ash, Mitchell. 1995. *Gestalt Psychology in German Culture, 1890-1967: Holism and the Quest for Objectivity*. Cambridge: Cambridge University Press.
Bell, John. 1982. "On the Impossible Pilot Wave." *Foundations of Physics* 12: 989-999.
Beller, Mara. 1983. "Matrix Theory Before Schrödinger: Philosophy, Problems, Consequences." *Isis* 74: 469-491.
Beller, Mara. 1985. "Pascual Jordan's Influence on the Discovery of Heisenberg's Uncertainty Principle." *Archive for History of Exact Sciences* 33: 337-349.
Beller, Mara. 1988. "Experimental Accuracy, Operationalism, and Limits of Knowledge — 1925 to 1935." *Science in Context* 2: 147-162.
Beller, Mara. 1990. "Born's Probabilistic Interpretation: A Case Study of Concepts in Flux." *Studies in History and Philosophy of Scienc*e 21: 563-588.
Beller, Mara. 1999. *Quantum Dialogue: The Making of a Revolution*. Chicago: University of Chicago Press.
Beyerchen, Alan D. 1977. *Scientists under Hitler: Politics and the Physics Community in the Third Reich*. New Haven: Yale University Press.
Beyerchen, Alan. 1992. "What We Now Know about Nazism and Science." *Social Research* 59: 615-641.
Beyler, Richard Henry. 1994. "From Positivism to Organicism: Pascual Jordan's Interpretations of Modern Physics in Cultural Context." Ph.D. dissertation, Harvard University.
Beyler, Richard H. 1996. "Targeting the Organism: The Scientific and Cultural Context of Pascual Jordan's Quantum Biology, 1932-1947." *Isis* 87: 248-273.
Beyler, Richard. 2003. "The Demon of Technology, Mass Society, and Atomic Physics in West Germany, 1945-1957." *History and Technology* 19: 227-239.
Bloor, David. 1981. "The Strengths of the Strong Programme." *Philosophy of the Social Sciences* 11: 199-213. 9

vom Bruch, Rüdiger, and Brigitte Kaderas, ed. 2002. *Wissenschaften und Wissenschaftspolitik: Bestandaufnahme zu Formationen, Brüchen und Kontinuitäten im Deutschland des 20. Jahrhunderts*. Stuttgart: Franz Steiner.
Brush, Stephen. 1980. "The Chimerical Cat: Philosophy of Quantum Mechanics in Historical Perspective." *Social Studies of Science* 10: 393-447.
Carson, Cathryn. 2003. "Objectivity and the Scientist: Heisenberg Rethinks." *Science in Context* 16: 243-269.
Cartwright, Nancy. 1988. "Philosophical Problems of Quantum Theory: The Response of American Physicists." In *The Probabilistic Revolution*, ed. Lorenz Krüger, Gerd Gigerenzer, and Mary S. Morgan, Vol. 2, *Ideas in the Sciences*, 417-435. Cambridge, MA: MIT Press.
Cassidy, David C. 1992. *Uncertainty: The Life and Science of Werner Heisenberg*. New York: W.H. Freeman.
Coen, Deborah Rachel. 2004. "A Scientific Dynasty: Probability, Liberalism, and the Exner Family in Imperial Austria." Ph.D. dissertation, Harvard University.
Cross, Andrew. 1991. "The Crisis in Physics: Dialectical Materialism and Quantum Theory." *Social Studies of Science* 21: 735-759.
Cushing, James. 1994. *Quantum Mechanics, Historical Contingency and the Copenhagen Hegemony*. Chicago: University of Chicago Press.
Darrigol, Olivier. 1992. *From c-Numbers to q-Numbers: The Classical Analogy in the History of Quantum Theory*. Berkeley: University of California Press.
Daum, Andreas. 1998. *Wissenschaftspopularisierung im 19. Jahrhundert: Bürgerliche Kultur, naturwissenschaftliche Bildung und die deutsche Öffentlichkeit 1848-1914*. München: R. Oldenbourg.
Dresden, M. 1987. *H. A. Kramers: Between Tradition and Revolution*. New York: Springer.
Eckert, Michael. 1993. *Die Atomphysiker: Eine Geschichte der theoretischen Physik am Beispiel der Sommerfeld-Schule*. Braunschweig: Vieweg.
Enz, Charles P. 2002. *No Time to be Brief: A Scientific Biography of Wolfgang Pauli*. Oxford: Oxford University Press.
Fischer, Klaus. 2000. "Repression und Privilegierung: Wissenschaftspolitik im Dritten Reich." In *Im Dschungel der Macht: Intellektuelle Professionen unter Stalin und Hitler*, ed. Dietrich Beyrau, 170-194. Göttingen: Vandenhoeck & Ruprecht. 10

Forman, Paul. 1967. “The Environment and Practice of Atomic Physics in Weimar Germany: A Study in the History of Science.” Ph.D. dissertation, University of California, Berkeley.
Forman, Paul. 1971. “Weimar Culture, Causality, and Quantum Theory, 1918-1927: Adaptation by German Physicists and Mathematicians to a Hostile Intellectual Environment.” *Historical Studies in the Physical Sciences* 3: 1-115.
Forman, Paul. 1973. “Scientific Internationalism and the Weimar Physicists: The Ideology and its Manipulation in Germany after World War I.” *Isis* 64: 151-180.
Forman, Paul. 1974. “The Financial Support and Political Alignment of Physicists in Weimar Germany.” *Minerva*: 39-66.
Forman, Paul. 1984. “*Kausalität, Anschaulichkeit,* and *Individualität,* or How Cultural Values Prescribed the Character and the Lessons Ascribed to Quantum Mechanics.” In *Society and Knowledge: Contemporary Perspectives in the Sociology of Knowledge,* ed. Nico Stehr and Volker Meja, 333-347. New Brunswick: Transaction Books.
Forman, Paul, John L. Heilbron, and Spencer Weart. 1975. “Physics circa 1900: Personnel, Funding, and Productivity of the Academic Establishments.” *Historical Studies in the Physical Sciences* 5: 1-185.
Hall, Karl Philip. 1999. “Purely Practical Revolutionaries: A History of Stalinist Theoretical Physics.” Ph.D. dissertation, Harvard University.
Harrington, Anne. 1996. *Reenchanted Science: Holism in German Culture from Wilhelm II to Hitler*. Princeton: Princeton University Press.
Harwood, Jonathan. 1993. *Styles of Scientific Thought: The German Genetics Community 1900-1933*. Chicago: University of Chicago Press.
Harwood, Jonathan. 1996. “Weimar Culture and Biological Theory: A Study of Richard Woltereck (1877-1944).” *History of Science* 34: 347-377.
Heilbron, J.L. 1985. “The Earliest Missionaries of the Copenhagen Spirit.” *Revue d’histoire des sciences* 38: 195-230.
Heilbron, J.L. 1986. *The Dilemmas of an Upright Man: Max Planck as Spokesman for German Science*. Berkeley: University of California Press.
Heilbron, John L., and Thomas S. Kuhn. 1969. “The Genesis of the Bohr Atom.” *Historical Studies in the Physical Sciences* 1: 211-290. 11

Hendry, John. 1980. “Weimar Culture and Quantum Causality.” *History of Science* 18: 155-180.
Hendry, John. 1984. *The Creation of Quantum Mechanics and the Bohr-Pauli Dialogue*. Dordrecht: D. Reidel.
Hessenbruch, Arne. 2000. “Science as Public Sphere: X-Rays Between Spiritualism and Physics.” In *Wissenschaft und Öffentlichkeit in Berlin, 1870-1930*, ed. Constantin Goschler, 89-126. Stuttgart: Steiner.
Hopwood, Nick. 1997. “Biology Between University and Proletariat: The Making of a Red Professor.” *History of Science* 35 (1997): 367-424.
Ito, Kenji. 2002. “Making Sense of Ryoshiron (Quantum Theory): Introduction of Quantum Mechanics into Japan, 1920-1940 (Yoshio Nishina).” Ph.D. dissertation, Harvard University.
Jurkowitz, Edward. 2005. “Planck’s unification of physics through principles.” Manuscript.
Kirchhoff, Jochen. 2003. “Die Notgemeinschaft der Deutschen Wissenschaft / Deutsche Forschungsgemeinschaft, 1920-1934: Schwerpunktlegungen in der Forschungspolitik der Weimarer Republik.” Ph.D. dissertation, Ludwig-Maximilians-Universität München.
Kojevnikov, Alexei. 1999. “Freedom, Collectivism, and Quasiparticles: Social Metaphors in Quantum Physics.” *Historical Studies in the Physical and Biological Sciences* 29: 295-331.
Kraft, P., and P. Kroes. 1984. “Adaptation of Scientific Knowledge to an Intellectual Environment. Paul Forman’s ‘Weimar Culture, Causality, and Quantum Theory, 1918-1927’: Analysis and Criticism.” *Centaurus* 27: 76-99.
Kuhn, Thomas S. 1978. *Black-Body Theory and the Quantum Discontinuity, 1894-1912*. New York: Oxford University Press.
Kuhn, Thomas S., John L. Heilbron, Paul Forman, and Lini Allen. 1967. *Sources for History of Quantum Physics: An Inventory and Report*. Philadelphia: American Philosophical Society.
McCormmach, Russell. 1982. *Night Tthoughts of a Classical Physicist*. Cambridge, MA: Harvard University Press.
Mehra, Jagdish, and Helmut Rechenberg. 1982ff. *The Historical Development of Quantum Theory*. Multiple volumes. New York: Springer.
Metzler, Gabriele. 2000. *Internationale Wissenschaft und nationale Kultur: deutsche Physiker in der internationalen Community 1900-1960*. Göttingen: Vandenhoeck & Ruprecht.
von Meyenn, Karl, ed. 1994. *Quantenmechanik und Weimarer Republik*. Braunschweig: Vieweg. 12

Mosse, George L. 1964. *The Crisis of German Ideology: Intellectual Origins of the Third Reich*. New York: Grosset & Dunlap.
Nye, Mary Jo. 1997. “Aristocratic Culture and the Pursuit of Science: The De Broglies in Modern France.” *Isis* 88: 397-421.
Nyhart, Lynn. 1998. “Civic and Economic Zoology in Nineteenth-Century Germany: The ‘Living Communities’ of Karl Möbius.” *Isis* 89: 605-630.
Pauli, Wolfgang. 1979ff. *Wissenschaftlicher Briefwechsel mit Bohr, Einstein, Heisenberg u.a.* Multiple volumes. Ed. Armin Hermann, Karl von Meyenn, and Victor F. Weisskopf. Berlin: Springer.
Pestre, Dominique. 1984. “Les convictions culturelles et épistemologiques des physiciens français: Etude d’un ‘socle archéologique.’” Chapter in *Physique et physiciens en France 1918-1940*, 173-207. Paris: Editions des archives contemporaines.
Ringer, Fritz K. 1969. *The Decline of the German Mandarins: The German Academic Community, 1890-1933*. Cambridge, MA: Harvard University Press.
Ringer, Fritz. 1986. “Differences and Cross-National Similarities among Mandarins.” *Comparative Studies in Society and History* 28: 145-164.
Robertson, Peter. 1979. *The Early Years: The Niels Bohr Institute, 1921-1930*. Copenhagen: Akademisk Forlag.
Sanchez-Ron, José Manuel, trans. 1984. *Cultura en Weimar, causalidad y teoría cuántica, 1918-1927: Adaptación de los físicos y matemáticos alemanes a un ambiente intelectual hostil*. Madrid: Alianza.
Schiemann, Gregor. 1996. “Wer beeinflußte wen? Die Kausalitätskritik der Physik im Kontext der Weimarer Kultur.” In *Intellektuelle in der Weimarer Republik*, ed. Wolfgang Bialas and George G. Iggers, 349-367. Frankfurt: Peter Lang.
Schirrmacher, Arne. 2002. “The Establishment of Quantum Physics in Göttingen 1900-24: Conceptional Preconditions – Resources – Research Politics.” In *History of Modern Physics*, ed. H. Kragh et al., 295-309. Turnhout: Edition Brepols.
Schirrmacher, Arne. 2003. “Die Entwicklung der Sozialgeschichte der modernen Mathematik und Naturwissenschaft und die Frage nach dem sozialen Raum zwischen Disziplin und Wissenschaftler.” *Berichte zur Wissenschaftsgeschichte* 26: 17-34. 13

Schweber, S.S. 1986. “The Empiricist Temper Regnant: Theoretical Physics in the United States 1920-1950.” *Historical Studies in the Physical and Biological Sciences* 17:1: 55-98.
Seth, Suman. 2003. “Principles and Problems: Constructions of Theoretical Physics in Germany, 1890-1918.” Ph.D. dissertation, Princeton University.
Shapin, Steven. 1992. “Discipline and Bounding: The History and Sociology of Science as Seen through the Externalism-Internalism Debate.” *History of Science* 30: 333-369.
Staley, Richard. 2005. “On the Co-Creation of Classical and Modern Physics.” Isis 96: 530-558.
Stern, Fritz. 1961. *The Politics of Cultural Despair: A Study in the Rise of the Germanic Ideology*. Berkeley: University of California Press.
Stölzner, Michael. 2001. “Die Kausalitätsdebatte in den *Naturwissenschaften*: Zu einem Milieuproblem in Formans These.” In *Wissensgesellschaft: Transformationen im Verhältnis von Wissenschaft und Alltag*, ed. H. Franz, W. Kogge, T. Möller, and T. Wilholt, 85-128. Bielefeld: Institut für Wissenschafts- und Technikforschung.
Timmerman, Carsten. 2001. “Constitutional Medicine, Meoromanticism, and the Politics of Antimechanism in Interwar Germany.” *Bulletin of the History of Medicine* 75: 717-739.
Trischler, Helmuth, and Mark Walker, ed. Forthcoming. *Physik in Deutschland 1920 bis 1970: Konzepte, Instrumentarien und Ressourcen der Forschung und Forschungsförderung im internationalen Vergleich*.
Vucinich, Alexander. 1980. “Soviet Physicists and Philosophers in the 1930s: Dynamics of a Conflict.” *Isis* 71: 236-250.
Wise, M. Norton. 1987. “How Do Sums Count? On the Cultural Origins of Statistical Causality.” In *The Probabilistic Revolution*, vol. 1, *Ideas in History*, ed. Lorenz Krüger, Lorraine J. Daston, and Michael Heidelberger, 395-425. Cambridge, MA: MIT Press.
Wise, M. Norton. 1994. “Pascual Jordan: Quantum Mechanics, Psychology, National Socialism.” In *Science, Technology and National Socialism*, ed. Monika Renneberg and Mark Walker, 224-254. Cambridge: Cambridge University Press.
Wise, M. Norton. Unpublished. “Forman reformed.” Manuscript.
Wolff, Stefan L. 2003. “Physicists in the ‘Krieg der Geister’: Wilhelm Wien’s ‘Proclamation.’” *Historical Studies in the Physical and Biological Sciences* 33: 337-368.