BOOKS: PHYSICS

The Nature of Matter

Martin L. Perl

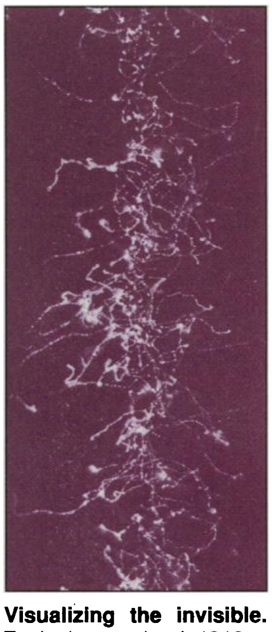
Image and Logic. A Material Culture of Microphysics. PETER GALISON. University of Chicago Press, Chicago, 1997. xxvi, 955 pp., illus. $90 or £71.95, ISBN 0-226-27916-2; paper, $34.95 or £27.95, ISBN 0-226-27917-0.

Peter Galison's *Image and Logic*, a history of the material culture of elementary particle physics and nuclear physics, presented a peculiar problem to this reviewer. I enjoyed reading the book and, although I have been an experimenter in particle physics for 40 years, I learned much about the detailed history of my material culture, including instrument technology and the organization and sociology of research. But what is the audience for this over 900-page book? Readers interested in the practice of scientific research, working scientists in general, historians and philosophers of science? Or only particle and nuclear physicists?

Elementary particle physics is the study of the smallest components of matter (electrons, photons, quarks, and protons) and of the elementary forces (such as gravity and electromagnetism). Nuclear physics is the study of the atomic nucleus and the nuclear force. Particle and nuclear physics, called microphysics by Galison, began as a single research field in the last decades of the 19th century, when Joseph Thomson finally clarified the nature of the electron, Wilhelm Röntgen discovered x-rays, and Henri Becquerel chanced upon radioactivity.

During the next half-century, new experimental technologies—cloud chambers, nuclear emulsions, particle counters, and electronic circuits—led to more discoveries and increased our understanding of the fundamental nature of matter. In the 1930s, the neutron was discovered with the use of natural radioactivity, and, with the help of the new particle accelerators, the structure of the atomic nucleus was elucidated. The phenomenon of nuclear fission was also discovered. In the 1930s and 1940s, two more elementary particles were detected in the cosmic rays that originate from outside our solar system: the muon, a more massive relative of the electron; and the pion, the first member of a vast family of particles known as mesons.

The first third of *Image and Logic* focuses on the material culture of the technologies that made these discoveries possible. Galison, the Mallinckrodt Professor of the History of Science and of Physics at Harvard University, emphasizes how and by whom the instruments were invented and developed. He includes many drawings and photographs, and does not hesitate to provide technical details. Consider nuclear emulsions. This technology is based on grains of silver compounds embedded in gelatin, a material similar to that coated on photographic film but much thicker. When a charged particle passes through the emulsion, a "latent image" of the particle's path remains. The latent image is then developed to give a visible image, much the way photographic film is developed. Galison discusses emulsion compositions, grain size, methods of developing the emulsions, and the struggles endured to manufacture thick emulsions of uniform sensitivity. He also explains the problems associated with detecting and measuring the tracks of particles in the developed emulsion. Teams of women, supervised by physicists, scanned these images with high-power microscopes. It was thought that the exacting but tedious job of scanning emulsions best suited the female temperament. Thus, Galison explores the organization and sociology as well as the technology of the experimental research.



C.T.R. WILSON, PROC. R. SOC. LONDON A 87, 277 (1912)

Visualizing the invisible. Typical x-ray cloud, 1912

In the course of these discussions of material culture, Galison introduces his concept of the difference between the "image" technologies, such as cloud chambers and nuclear emulsions, and the "logic" technologies of the particle counter and electronic circuit. The former show directly a picture or image of a particle passing through or interacting with matter; the latter provide electronic signals that must be interpreted with the use of logic.

Most of the remaining two-thirds of the book covers the past four decades. This period is characterized by enormous growth in the complexity, size, and cost of experimental equipment in elementary particle research, exemplified by the large bubble chambers (image technology), hybrid electronic detectors (logic technology), and gigantic particle accelerators—as well as by the experimental groups themselves, including hundreds of physicists, engineers, technicians, and computer programmers.

Galison devotes considerable space to explaining how this growth was stimulated by the success of weapons technology–related research during World War II, which led to the development of radar, nuclear reactors, and the fission bomb. Here, he provides fresh material, but no new insights into the origins of "big science."

Again, Galison devotes substantial space to the temporary triumph in the 1960s of the bubble chamber (image) technology and the later ascendance of the hybrid electronic detector (logic) technology. This concept of image versus logic is overemphasized; it is useful in illuminating the development of the material culture in this field, but it does not apply to other research technologies.

The most successful aspect of the book is the explanation, by example, of how experimental science is actually performed. Theoretical insight and experimental ideas are both important, but, in the end, the progress of science depends on technology. Furthermore, progress relies not only on the invention of a new technology but on its continual improvement. And, if one technology cannot accomplish some task, then a new one must be developed. For example, the existence of neutrinos was proposed by Wolfgang Pauli in the 1930s. However, because neutrinos rarely interact with matter, they could not be detected until after 1950, when particle detectors with large amounts of material that would interact with the rare neutrino were gradually developed.

I believe this book's explicit lessons on the nature, importance, and practice of experimental technology will be the most valuable to the reader. Practicing scientists—particle physicists or gene sequencers—can get a broader view of their own experimental technology. Students of the history or philosophy of science who have overdosed on paradigms and the nature of scientific truth will find detailed material for more realistic thoughts about the practice of science. And the general reader who is content to skip some chapters will find fascinating insights into how experimental science, small or big, is really done.

The author is a professor of physics at the Stanford Linear Accelerator Center, Stanford University, Stanford, CA 94309, USA. E-mail: martin@slac.stanford.edu