minicomputers and microcomputers. Minicomputers were a downwards development from large, general-purpose, stored-program machines, whereas microcomputers were an upwards development from discrete electronics components. Both minis and micros retain the technical flavour of their respective forebears, together with a contrasting aura of formality versus informality, structure versus improvisation. Microprocessors and their related chip sets have become sufficiently cheap for improvisation to be, if not academically respectable, then at least cost-effective in terms of time and effort. Furthermore, the capability for ingenious local control now offered by a microprocessor is surely the answer to every experimental scientist's prayer. Chips such as the Z80 ought to be as commonly and as casually used as the bunsen burner of yesteryear.

It is in this spirit that the book by Sargent and Shoemaker should be read. It is unashamedly biased towards the widely-used Z80 family of microprocessors, with the TRS-80 system predominating. Practical circuits and assembly-code sequences are given for dealing with AC control, A/D/A conversion, signal averaging, stepper motors, displays etc., and serial communication using a variety of physical media. There is an intriguing series of 14 step-by-step experiments (hardware and software) for the enthusiast armed with a Z80 starter kit. This book, like the Z80, should be bought, used well and then disposed of when it becomes obsolete. □

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mass with velocity was not a theory of electromagnetic mass alone, but of all mass. Miller gives a good picture of this situation, in which special relativity, as a theory in its own right, had to wait about five years for widespread acceptance.

On a couple of points of detail, I was sorry that Miller (p.134) repeated the old myth that Boltzmann's constant and Avogadro's number were not reliably known before 1905 (or, presumably, until they could be inferred from Millikan's precise measurements of *e* around 1915). In 1900 Planck published values of these quantities differing by less than 3 per cent from today's. Also, I was puzzled by Miller's assertion (p. 266) that the Ives–Stilwell experiment of 1938 remains the only positive proof of time dilation. Surely the Hafele–Keating experiment (1971), with atomic clocks carried around the world in opposite directions, was as direct a demonstration as one could wish for.

. . . and then came Einstein . . .

A.P. French

Albert Einstein's Special Theory of Relativity: Emergence (1905) and Early Interpretation (1905–1911). By Arthur I. Miller. Pp.466. ISBN hbk 0-201-04680-6; ISBN pbk 0-201-04679-2. (Addison-Wesley: 1981.) Hbk \$39.50, £20.10; pbk \$27.50, £13.45.

PROFESSOR Miller has undertaken an interesting and worthwhile task in this detailed study of the historical background and the initial reception of Einstein's special relativity theory, and in particular of his epoch-making first paper on this subject in 1905. In his introduction, Miller makes the telling point that:

> . . . it is difficult to imagine a teacher of English who has never read one of Shakespeare's plays. But few people today, including physics researchers, teachers of physical science or philosophers of science, have carefully read Einstein's relativity paper of 1905 . . .

— this despite its immense impact, not only in its particular field, but also on the whole philosophy of theoretical science. Miller also remarks that:

> . . . While many in-depth analyses of the works of high literature are available to humanistic scholars, physicists have virtually no access to analyses that guide the reader through the real and apparent complexities of a major scientific work, placing the work in its proper historic context . . .

It has been Miller's aim to provide within a single book a detailed exegesis of the 1905 paper, preceded by a full account of the developing situation in electromagnetic theory during the 15 years prior to its appearance. In a lengthy chapter which occupies over a quarter of the book, he takes the reader through the complex history of electrodynamics after Maxwell, as developed chiefly by Hertz, Lorentz, Abraham and Poincaré. At first, the problem was to reconcile an ether-based electromagnetic theory with the optical phenomena observed by Fizeau and Michelson. However, after the discovery of the electron in 1896/7, the quest began for an electrical theory of matter, including various specific theoretical expressions for the variation of electron mass with velocity — predictions that were diligently compared with the contemporaneous experimental findings of Kaufmann.

Then came Einstein. Miller's reminder of the complexity and artificiality into which classical electrodynamics had been driven helps one to appreciate even better the magnitude of Einstein's genius. Reading the opening sections of his 1905 paper is like going into a side room for a quiet and thoughtful conversation after being at a noisy, crowded cocktail party. His profound and deceptively simple insights led, as we all know, to a straightforward, exact and complete explanation of all the phenomena that had so exercised the experts. Miller conducts us through Einstein's paper, section by section, with appropriate reference to relevant contemporary work and the reactions of other physicists. Two features of these reactions seem to stand out. One is the failure of the world of physics in 1905 to recognize or acknowledge the conceptual gulf between Einstein's approach and the ether-based theories of Lorentz. The other is a similar failure to see that Einstein's results, based as they were on fundamental concepts of space and time, transcended the limits of electrodynamics in particular. Thus, for example, his formula for the variation of

I have a further, more substantial criticism of Miller's treatment. He quotes what Einstein once said about Mach's deep insights into the development of mechanics, even where specific knowledge of what the early workers thought or did was lacking. Miller seems to try to emulate this in the case of Einstein. In particular, with regard to Kaufmann's measurements of electron mass as a function of velocity, Miller suggests that Einstein knew of these results in 1905, but failed to mention them because they conflicted with the predictions of his theory. This seems to me entirely out of character for Einstein, and represents an unwarranted aspersion on his scientific integrity. Conjectures of this sort can only detract from an otherwise scholarly discussion. It seems far more likely that, just as in his development of the photoelectric equation, Einstein did not know or care very much about the imperfect experimental data; the foundations of his theorizing were much deeper and stronger. Except for this criticism, however, I would recommend Miller's book to anyone who wishes to find a detailed picture of the antecedents and birth of special relativity. □

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