Two impressions of relativity. The pseudometric view of Hermann Minkowski depends on a global network of clocks (here calendars) and the transport of chronometers (left). The causal view of Revol't Pimenov (right) does not require a coordinate system, but relies solely on the causal relation between identifiable events such as the disturbance D and the observation at E. Photos by Joshua Barnes.

lems of energy loss by a fast electron in a solid by various mechanisms, a subject invariably treated by more or less formal mathematical methods, typically via perturbation theory.

A final point about the Baynham and Boardman monograph. Impelled, I suppose, by their dis-ease with the unrewarding technological situation as regards plasmas in solids, the authors come out with this sentence near the conclusion of the book, (page 161): ". . .the Gunn effect which is, of course, a form of plasma instability." It is nothing of the kind. It is a consequence of a distinctive band structure and Coulomb's law. Although indeed a subhandful of theoretical papers have cast the Gunn problem into a plasma mold, they came late in the game and have had utterly no influence on the course of Gunn and Gunn-like events. One might as well proclaim that all transistor devices are within the purview of solid-state plasmas. These are semantic ploys that just don't advance the cause. However, to redress the balance, in a book as truly valuable as that of Baynham and Boardman it is very, very easy to forgive a single sentence of exaggeration.

References

1. PHYSICS TODAY, February 1971, page 47.
2. RCA Review, **27**, 98 (1966).
3. The remaining four are also in the RCA Review; **27**, 600 (1966), **28**, 634 (1967), **30**, 435 (1969) and September 1971 (in press).

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Seminars in Mathematics of the V. A. Steklov Mathematical Institute, Vol. 6: Kinematic Spaces

By R. I. Pimenov
185 pp. Consultants Bureau
New York, 1970. $22.50

What is relativity *really* about? Minkowski makes us think we live in a space endowed with a pseudometric function. But some (such as A. A. Robb, Alexandr Alexandrov, Erik Zeeman, and E.H. Kronheimer and Roger Penrose suggest that our space is endowed with a local succession, precedence or causal relation expressing "the fundamental and general fact that each phenomenon acts upon some others" (Alexandrov). Revol't Pimenov calls such spaces *kinematic spaces*. Almost all works on relativity follow the pseudometric trail, as a result of historical circumstances. For centuries after Euclid it was believed we lived in a three-dimensional metric world, and surely this influenced mathematicians like Riemann to develop the differential geometry of metric spaces into the powerful conceptual tool that Einstein found ready for him. But now we understand Euclid's misunderstanding, and a mathematician who wishes to be relevant should give equal time to the study of spaces provided with a causal rather than pseudometric structure. Pimenov has provided us with a most comprehensive monograph on these. The only other books in the area at all are those of Robb on relativity (which covers much less ground) and H. Buseman on timelike spaces (which is less physical).

Let me explain why I resonated strongly with this approach of Pimenov's when I first saw it, and welcome this translation now, opaque as it is in patches. I think the difference between the pseudometric and causal conceptions of the world is significant. It is not merely a choice between two axiomatizations of one underlying theory. That it matters for learning is obvious, and perhaps we should try teaching relativity in causal terms. But what concerns me most is the Einstein problem:

We may picture physical reality as covered by the various domains of physical theory as the earth is by continental masses, tectonic plates. One lesson from Einstein's life is that theorectical upheavals like earthquakes come from where these masses clash: mechanics against thermodynamics (Brownian motion), electromagnetism against mechanics (special relativity), mechanics against geometry (gravitational theory). For most of Einstein's later life he wrestled with the problem of the confrontation of macroscopic physics (including the theory of gravity with microscopic (quantum theory). I call this the Einstein problem. I do not think it is closed. It seems to me we still lead a schizoid conceptual life, with neither half-world viable.

Why do I think this causal approach pertinent to the Einstein problem? In brief, because it is so much more operational. Here I try to take a second lesson from Einstein, and Heisenberg as well. In our search for the next physical theory it is important to put existing theory into the right form. Schwinger has emphasized this for quantum theory, citing how the Hamilton-Jacobi form of classical mechanics made possible Schrödinger's formal leap into wave mechanics, and it must be true for space-time theory as well. We infer from the experiences of Einstein and Heisenberg that the right form is apt to be expressible in terms of basic concepts close to operational practice. So when we develop the metric formulation fully, with its underlying topological and differential structures, and compare it with the quantum picture of the world, it becomes hard for me to believe the metric path is the right one. The causal formulation, on the other hand, makes the geometry of the world a consequence of the pattern of dynamical interactions, very close to Einstein's own operational analysis in terms of light signals. The two formulations suggest quite different paths for the future, and the causal path appears greener to me. This is a subjective view, and I do not project it upon Pimenov.

Pimenov sets up a detailed taxonomy of kinematic spaces. (The work pleads for an index, at least of definitions; in vain.) One after the other he turns on a local causal order, a topology, a pseudometric, a coordinatization, an affine connection and a material distribution, each of which may in special cases be determined by the preceding. The work is too rich in geometrical ideas to summarize here. It is mathematical in content (Definition, Theorem, Proof) with frequent appeal to physics for motivation, and overlaps Busemann's book, which appeared a little earlier. Pimenov deals with Newtonian kinds of kinematic space, in which the causal relation tells little about the geometry, as well as Einsteinian, where the causal relation tells much about the geometry. This leads him to the more general conception of semi-Riemannian geometry, where the metric need not fully determine the affine connection and signals may propagate instantaneously in some directions, a degenerate limit of Riemannian geometry. One of the most interesting models of this kind he calls an "electrodynamic space." It is a plausible five-dimensional model of electromagnetism, with significant advantages over the Kaluza kind of model. Other internal degrees of freedom of current interest besides electric could also be modeled interestingly in semi-Riemannian spaces.

His frequent bibliographical discussions show Pimenov knows the work of other relativists well, but my informal survey suggests that the reverse is not true; and I find ideas I published as virgin were his long before. This is not entirely surprising because he has been confined for much of his career, and is in prison now; a consequence, it seems, of unofficial publication, and the cause of a deplorable lack of contact with the scientific community. But the resulting deprivation is not Pimenov's alone.

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Worked Examples in X-Ray Spectrometry

By **R. H. Jenkins, J. L. DeVries**
127 pp. Springer-Verlag, N. Y.
1970. 5.80

This little volume is clearly designed to accompany and supplement the authors' earlier work on x-ray spectrometry and their forthcoming work on x-ray diffractometry. Worked examples, carefully selected and clearly explained, can obviously be of great help to beginners and to those to whom suitable academic training is not readily available. Both authors have had extensive experience in teaching students in various schools and seminars organized by N. V. Philips Co. of Eindhöven, Holland. Problems in the book have been selected with care and have been organized in a reasonable fashion. There are five sections dealing with spectra, instrumentation, counting statistics, quantitative analysis and "miscellaneous." A relatively small number of problems are of a general type; others deal with x-ray spectrometry and diffractometry in approximately equal numbers. The problems are graded in order of increasing difficulty. So far, so good.

Unfortunately, the book is marred by an intolerable number of typographical and other errors. A random check of some 20 problems revealed serious errors in almost every one. Also, the figures accompanying the text are often unclear. Explanatory texts directly beneath each figure would be of help to the reader, as would concise and meaningful titles for the many Tables.

In its present form this work cannot be recommended. It could, however, be recommended and serve a useful purpose if adequate care is taken in the preparation of a second edition.

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Theoretical Physics: An Advanced Text, Vol. 1: Theory of the Electromagnetic Field Theory of Relativity

By **B. G. Levich**
395 pp. Wiley, New York,
1971. $15.50

Here we see the first volume in a series of four books on theoretical physics written for undergraduates and beginning graduate students in physics who are not able to cope with texts of the Landau and Lifshitz calibre. The author, Benjamin G. Levich, is associated with the Institute of Electrochemistry of the Soviet Academy of Sciences, and these books, published in Russia in 1962, have evidently found wide appeal as texts. Volume 1 of Levich's course deals with electrodynamics of classical systems, and might be compared with the third volume of the famous Sommerfeld lecture series. As might be expected, there are few surprises in the choice of material and exposition in Levich's text.

One good feature of this book is its treatment of radiation theory, which the student will find quite detailed. As an example, a nice derivation of the quadrupole radiation formula, $1 = (\dddot{D}_{\alpha\beta})^2 / 180c^5$, is given on page 133. Another good chapter is that dealing with the motion of particles in electric and magnetic fields, drift of particles in crossed **E** and **H** fields, and magnetic