

would such ideas as second quantization, mass and charge renormalization, or QCD again precipitate upon slow cooling?

The trouble is that physics is not a computer simulation. It is a real social process. The perpetuation of bad ideas and ignoring of good ones that goes on routinely in the current ice age is a real tragedy not only for abstract "science" but for our species. So gelid had the mental climate become that one hardly distinguishes individual minds any more. These seem to clump together into ever-growing teams and schools of thought—a sort of opalescence, as near a critical point.

One would like to be able to control the temperature parameter—to heat things up and anneal more slowly in order to precipitate something nearer to an "optimum science." The difficulty of this problem should not be underestimated. Every attempt by external forces (for example, government) to "strengthen science" turns out to mean strengthening the status quo in science and thus acts as a cooling agent. To the present, it would appear that no effective heating mechanism of an institutional nature has been devised (if we leave aside such breakthroughs as the posting of "THINK" signs). Perhaps some of the more inventive of your readers would like to cogitate on the matter.

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6/82

Can glass flow?

When I was looking for a picture that showed the flow of glass to illustrate my text, *Invitation to Physics*, I finally turned up an authoritative opinion that glass does not flow. These comments of John P. Hoxie, a consultant to the Corning Glass Works Archives, will be of interest to those readers who have followed the correspondence on this subject in *PHYSICS TODAY* (June, page 90). Hoxie wrote:

Glass has a low viscosity at the elevated temperatures involved with its melting and forming. Then it cools below red heat and the viscosity approaches infinite values. The glass technologist frequently uses viscosity language because it is useful in describing the annealing process and elimination of internal strains.

The data he supplied show that there is no possibility of internal movement in glass once it has dropped below 400 °C.

The other physical observation one may make regarding old windows relates to optical performance and

the glazier's compensation for uneven quality. Before 1890, most window glass was produced by hand blowing of cylinders, slitting and flattening them. Such cylinder blowing invariably yielded glass which tapered in thickness, and window panes were wedge-shaped with some prism effect. Where several small panes were mounted in a window sash, the thick edges should all be mounted in the same direction, such as toward the bottom. If the panes in a window were randomly oriented, a viewer would sometimes see a distant horizon as a jumpy line rather than a straight horizontal line.

The marvel that might be pointed out in a physics book is that early civilized man was able to produce a new material intelligently synthesized from natural ingredients, the specimens of which have maintained shape perfectly some 3500 years due to their rigid internal physical properties. The idea of glass somehow slumping at ordinary temperatures is a myth distinctly at odds with both the experience of archaeology and modern research into the nature of materials.

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8/82

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THE AUTHOR COMMENTS: I am grateful to Jay Pasachoff for continuing the discussion on glass creep. Window panes do not flow under the influence of gravity (a weak force) partly because room temperature (300 K) is too low compared to their glass transition temperature T_g (about 1000 K). However, as pointed out to me by R. E. Dietz of Bell Laboratories and R. G. Wheeler of the Applied Physics Department of Yale University, glass flow can be and is used to date and authenticate Chinese vases.¹ The porcelain ceramic glaze melts around 1200 K and it is flattened (or smoothed) over periods on the order of 500 years by the relatively strong force of surface tension.

Reference

1. C. and M. Beurdeley, *A Connoisseur's Guide to Chinese Ceramics* (Harper and Row, New York, 1974), page 180.

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11/82

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Meaningless embargo

Recently I participated in a six-week US-USSR scientific exchange at the I. V. Kurchatov Institute in Moscow, sponsored by the Department of Ener-

gy. During this time I collaborated with Dutch and Soviet scientists making measurements on a large tokamak as part of their controlled thermonuclear research program.

In the course of our work, I found that we could obtain a large and crucial increase in the sensitivity of our instrument by using an inexpensive (\$20.00) low-noise amplifier chip readily available commercially in the US and Europe. Then to my dismay I discovered that my home institute, the Princeton Plasma Physics Laboratory, could not send this to me as it had been placed under embargo as of January 1982. Moreover, their inquiries revealed that amplifiers that are nearly obsolete and cost only a few dollars each have now also been included in the embargo.

We purchased the amplifier chip we needed in Europe and had it shipped to Moscow. The official US position appeared even more ludicrous since the Dutch scientists with whom I worked had brought with them to Moscow a sophisticated and expensive data-gathering system, including advanced computer-controlled amplifiers.

This attempt to embargo such cheap and easily obtainable material is utterly meaningless in terms of interfering with technological progress in the USSR. The only possible aim is to foster among the American people a spirit of distrust and paranoia with respect to the USSR, a spirit completely contrary to that of the scientific exchange. This is one more piece of evidence that the Reagan administration, despite its public statements, is only interested in confrontation, not in cooperation and understanding.

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Soliton revolution

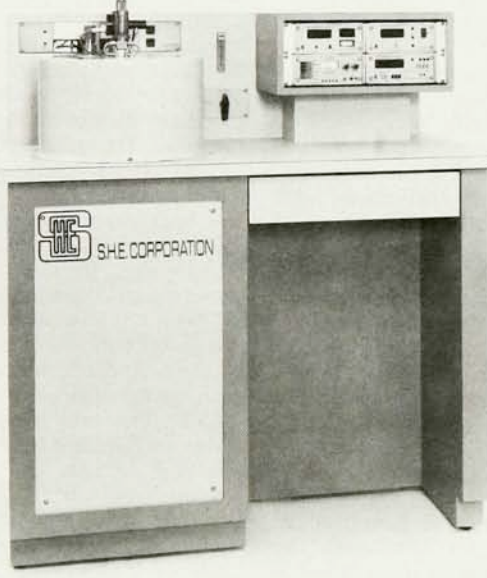
C.-H. Tze's introduction to the review of three books (June, page 55) that are a result of the "soliton revolution" in nonlinear physics omits important historical connections and a vital insight. I would like to set the record straight and illustrate the analytical-computational road—a new mode of working.

In 1834, John Scott Russell first observed solitary wave entities propagate from a suddenly stopped canal barge. They separated over long distances "... more and more apart the further they travel."¹ But although he recognized the importance of these "great waves of translation," the scientific and mathematical community ignored them! Even as recently as fifteen years ago, careful experiments by engineers produced similar transformations of periodically excited smooth waves into many solitary-like entities.

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Still no deep understanding of their remarkable nonlinear properties was forthcoming.

However, the breakthrough came in 1965 when the Korteweg-de Vries (KdV) nonlinear partial differential equation was solved numerically by Martin D. Kruskal and myself, with the assistance of Gary S. Deem.² This equation had been derived in 1895 as a model for small-but-finite amplitude unidirectional shallow water waves. We came upon this equation from a different road. We were trying to explain the long-time near-recurrence phenomenon observed by Fermi, Pasta and Ulam in their 1955 numerical solutions of long wavelength excitations of a nonlinear lattice. Kruskal³ also derived the KdV equation as a model for unidirectional long waves on a nonlinear lattice. The word "soliton" was coined and the concept introduced in our paper (1965), in which we also remarked on its potential applicability to "... lattice dynamics, plasma physics and electrodynamics."² These results catalyzed the efforts of the "Princeton group" which led to the exact linearization and solution of the KdV equation. The heroic period, 1965-1971, marks the true beginning of the "soliton revolution."⁴

The soliton concept was vividly captured on a computer-generated film in 1965. This has served as a source of inspiration, information and heuristic guidance to a wide community of scientists and engineers. Such modes of display can greatly enhance the possibility of innovation and discovery in physics and mathematics.⁴

As we can see, it was a long road from Russell's unexplained observations to the many interdisciplinary papers and books now appearing. As E. Chargaff noted, "It is in general true of every scientific discovery that the road means more than the goal. But only the latter appears in ordinary scientific papers."

References

1. R. Miura, *Solitons in Action*, K. Lonngren, A. Scott, eds., Academic, New York, 5 (1978).
2. N. J. Zabusky, M. D. Kruskal, *Phys. Rev. Lett.* **18**, 240 (1965).
3. M. D. Kruskal, *Proceedings of the I.B.M. Scientific Computing Symposium—Large Scale Problems in Physics*, 1963.
4. N. J. Zabusky, *J. Comput. Phys.* **43**, 195 (1981). A comprehensive review that gives the history of the discovery of the soliton and illustrates the new mode of working.

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9/82

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