HOW PHYSICS FOSTERED FREEDOM IN THE USSR

The discussion of aid to scientists from the former Soviet Union at the April APS meeting was very interesting and productive. It is easy to explain to physicists why they should support physics in the FSU. Physics is developed by the collective effort of physicists from many countries, and if the Soviet school of physics ceased to exist, that would be a blow to American physics as well. But another reason escaped general attention at the April meeting—a reason that not only physicists but also politicians should be aware of.

Physics and physicists played a very special role in the political life of the USSR. Biology, cybernetics and many other sciences were either crushed or not supported to the necessary extent during and after the Stalinist times. This did not happen with physics. Because of its importance for the development of the atomic bomb, physics was able to survive and develop, harmed to a much lesser degree by the dictatorship of official ideology. This circumstance gave rise to a very unusual phenomenon: The scientific culture associated with the Soviet school of physics became a culture of free political thought.

As a result, many leading dissidents in the USSR, such as Andrei Sakharov and Yuri Orlov, were physicists. Their role in the reorganization of the Soviet state is well known. Many physicists joined in the political activity and the fight for freedom in the years of *perestroika*. These people are well educated, and they are not afraid to make radical conclusions if they believe those conclusions are right. From their contacts with colleagues all over the world, they know much better than other people in the FSU the ways of development in Western society.

The process of political reconstruction in the FSU is not over yet, and the potential role of physicists should not be underestimated. There is no doubt that this process will produce many smart people who will quickly learn the basic principles of business. But it would take generations to reproduce the culture of clear and independent thinking that gave rise to such people as Sakharov. It would be a political mistake to allow that culture to disappear.

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Computopia, Here We Come

N. David Mermin's Reference Frame column of May 1991 (page 9) advocated a formal electronic bulletin board system as a means of circumventing recognized inadequacies of journals. The printed responses (January, page 13) are primarily of sociological interest, as evidence of a professional community's unwillingness to abandon familiar but antiquated institutions whose demise has been under way for decades. The technological issues, although obscured by surprising levels of computer anxiety and ignorance, are already settled.

Theory. Several readers wondered about how refereeing and revisions would work under Mermin's scheme. The irrelevance of refereed journals to ongoing research in the elementary-particle theory community has long been recognized. At least since the mid-1970s, the preprint distribution system has been the primary means of communication of new research ideas and results. In this community we have learned to determine from the title and abstract (and occasionally the authors) whether we wish to read a paper, and to verify necessary results rather than rely on the alleged verification of overworked or otherwise careless referees (such as ourselves on bad days). The small amount of filtering provided by refereed journals plays no effective role in our research. As for revisions, a system that allows ongoing corrections or addenda is manifestly preferable to one that does not, and can easily be implemented to assure that only those who so desire are kept up to date.

The hardware issue of mass storage no longer poses an obstacle. An average paper (without figures) requires 50 kilobytes to store. Hence one of the current generation of rapid-access gigabyte disk drives costing under $2000 can hold 20 000 papers—at an average cost of 10 cents per paper. Slower-access media for archival storage cost even less: A miniature video-8 cartridge, available from discount electronics dealers for under $7, can hold 2 gigabytes, that is, 40 000 such papers. The data equivalents of multiple years of most journals constitute a small fraction of what many experimentalists routinely handle on a daily basis, and the costs of data storage will only continue to diminish.

Since the storage is so inexpensive, it can be duplicated at numerous distribution points, minimizing the risk of loss due to accident or catastrophe, and facilitating worldwide network access. Backup procedures to preserve data do not ordinarily restrict access to modern computer systems, and the "electrical storms in Iowa" of concern to reader Richard Schultz do not affect distributed network access any more than they affect intercontinental telephone service. NSFNet runs 24 hours a day with virtually no interruptions, and transfers data at a rate of 1.5 megabytes/sec ($^{1}/_{30}$ sec per paper). Currently projected upgrades (see PHYSICS TODAY, January, page 54) to 45 Mbyte/sec in five years and a few gigabytes per second within a decade will be more than adequate to accommodate increased usage.

In the long term, electronic access to scientific research will be a major boon to developing countries, since the expense of connecting to an existing network is infinitesimal compared with that of constructing, stocking and maintaining libraries. The trend experienced over the past decade in the Western world, where data transmission lines have become as common as telephone service, and terminals and laser printers as common as typewriters and photocopy machines, could be repeated even more quickly as countries in Eastern Europe and the third world develop electronic infrastructures. In the short term they will be no worse off than they already are, receiving information via conventional means from the nearest redistribution point. Conformity to a uniform computer standard both in the US and abroad to communicate results to the largest possible audience should impose no greater a burden than communication using a non-native language—English—already imposes on the majority of the world.

Software for figures has not yet been standardized, but the vast majority of networked physics institutions have screen previewers and laser printers that display and print Postscript files created by a wide variety of graphics programs. High-resolution digital scanners will soon become as commonplace as fax machines and will permit inclusion of figures of arbitrary origin. With appropriate data compression and Postscript conversion, figures would typically increase the paper storage requirements cited above by an inconsequential factor of 2.

Concerns about interference from malevolent hackers are hopelessly exaggerated. The difference between executable and text files is known to managers of most systems, if not to their users. An archive is easily rendered immune to corruption, and minimal precautions can assure users of bulletin board systems that their system resources are not endangered. Anonymous servers running on Internet have for years allowed the academic community to openly exchange executable software far more susceptible to malfeasance, and their safeguards have proven effective.

It is straightforward to implement charges for such a system if desired, via either flat access rates or monitored usage rates. Piggybacked on existing network resources, however, such a system would cost so little to set up and maintain that it could be offered virtually free. Overburdened terminal resources at libraries are not an issue, since access would typically be via the terminal or workstation on one's desk or in the nearest computer room.

Experiment. So rather than fret about the impossibility of an article database, I spent a couple of afternoons last summer writing software to assess the feasibility of automating such a system. The software is rudimentary and allows users with minimal computer literacy to communicate e-mail requests to the Internet address hep-th@xxx.lanl.gov ("hep-th" stands for high-energy physics theory). Remote users submit and replace papers, obtain papers and listings, get help on available commands, search the listings for author names, and so on. The system also allows anonymous access to the papers and the listings directories. No papers have been lost or corrupted. The papers are submitted as Tex

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source files, already the community's universally accepted word processing format. Figures are typically submitted as Postscript files or generated within a Tex-oriented picture environment.

The initial user base was assembled from preexisting e-mail distribution lists in the subject of two-dimensional gravity and conformal field theory. Starting from a subscriber list of 160 addresses in mid-August 1991, hep-th grew after six months to serve over 900 subscribers covering every continent except Antarctica, while the subject range broadened to encompass most of formal quantum field theory and string theory. (An alternate bulletin board for particle phenomenology papers, hep-ph@xxx.lanl.gov, has recently been established as well.) The system provides a daily listing of titles and abstracts of new papers received. It now receives an average of three new papers per day, responds to an average of 300 requests per day, and transmits more than 600 copies of papers on peak days. Internet access time is typically a few seconds. Numerous institutional addresses have subscribed to receive every paper automatically so that secretaries can acquire valuable practice processing Tex papers to place on preprint shelves.

The system runs as a background job on a small Unix workstation that is primarily used for other purposes, and it places no noticeable drain on cpu resources. It will require about 50 megabytes per year (that is, less than \$100 per year) for storing papers, including figures. Its network usage is less than 10^{-5} of the lanl.gov backbone and so places a negligible drain on local network resources. It requires little intervention and recently ran unattended for five weeks while I was abroad. It could easily be scaled up by at least two orders of magnitude in usage on the basis of existing (that is, borrowed) resources. It is difficult to estimate the potential for dedicated systems of the future only because the resources of the current, experimental one (run free of charge) are so far from saturation.

The system in its present form was not intended to replace journals, but only to organize a haphazard and unequal distribution of electronic preprints. It is increasingly used as an electronic journal, however, evidently because electronically retrieving a computer file of a paper is more convenient than physically retrieving a paper from a file cabinet. Besides minimizing geographic inequalities by eliminating the boat-mail gap between continents, the system institutes a form of democracy in research wherein access to new results is granted equally to beginning graduate students and seasoned operators. No longer is it crucial to have the correct connections or to be on exclusive mailing lists to be kept informed of progress in one's field. The pernicious problem of lost or stolen preprints experienced by some large institutions is definitively exorcised as well. Communication among colleagues at the same institution may even be enhanced, since they frequently cross-request one another's preprints from the remote server (the reasons for which in general I hesitate to contemplate).

Systems such as the one I describe are already being implemented in other disciplines. Moreover, the current software is freely available to anyone with the requisite disk and network resources. These systems are still primitive, and are only tentative first steps in the optimal direction. The obvious next step is a local, menu-driven interface, automatically connected to the nearest central server, that transparently pipes selected papers through text formatters directly to a screen previewer or printer. (Such software is already running on my local network and parallels available software that accesses other network services, such as weather information.) Perhaps the centralized databases and further software development will ultimately be administered and systematized by publishing institutions such as AIP, the British Institute of Physics (which has expressed interest) and others, if they are prescient enough to reconfigure themselves for the inevitable.

[*Note added in proof:* Hep-th is the system Mermin alludes to in his April 1992 Reference Frame column. Since this letter was written, at least eight more bulletin boards running similar software have been established.]

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I would like to second N. David Mermin's suggestion (May 1991, page 9, and April 1992, page 9) that most paper journals should be replaced by electronic ones, and to point out some additional arguments in its favor.

An advantage of electronic publishing that has not been adequately emphasized is the awesome ability (well known to users of on-line literature-search services) of computers to rapidly sort and search through large amounts of data. The worst problem facing any user of the scientific literature today is "information overload." Users combat this in several ways: by reading only journals with high reviewing standards or reading only articles by authors they know to be competent or whose addresses inspire confidence. But these selection methods are primitive, so we all end up spending large amounts of time reading papers that contain nothing of interest but have somehow "beaten the system." A simple electronic bulletin board would just make these problems worse, as was pointed out by some of the letters responding to Mermin's initial suggestion. However, a well-designed electronic publishing system could combine the functions of subject searching, peer reviewing and author selectivity into a single very flexible and "productivity enhancing" (in the lingo of the software business) system.

Mermin suggests that the system allow subject searching and collect comments on a paper that could be downloaded with the paper, but this only scratches the surface of what such a system could do. It could emulate the existing peer review system by allowing a user to adjust a software filter that would not only select certain subjects but compute a "quality index" from readers' ratings (submitted with their comments) and require that this index exceed some threshold. A user could set the filter to simulate *Physical Review Letters* by requiring a length under four pages and two very high ratings from a specified group of reviewers, or another journal by requiring only one high rating from any reviewer. Or the user could choose criteria that are not used by any existing journal. To see new papers very close to their areas, most users would set filters to pass them (based on subject, key words or author) without requiring previous review. But users could avoid wasting time on crackpots or unimaginative boilerplaters by filtering out authors whom they or a trusted group of colleagues had given several negative reviews.

As Mermin has suggested, the main reason for the existence of journals is not to publish papers but to classify them for later counting by search committee, deans and Federal granting agencies. Many deans already use the *Science Citation Index* for evaluation purposes. The proposed system would be much more informative. We might even find that the number of repetitive papers submitted would decline rapidly once deans and contract monitors knew how few people read them.

Thought would have to be given to preventing authors from "stuffing the ballot box" with favorable reviews by friends. One could easily construct algorithms to test for this sort of behavior; the fear of being publicly identified would then deter most authors from such schemes. A friend who *did* do such a "favor" would either have to be anonymous—and an anonymous favorable review would create immediate suspicion—or risk being asked to explain an obscure point in the paper a later, negative reviewer. In addition to rating the paper, reviewers could also be given the opportunity to anonymously rate the integrity of earlier reviews. All this could be taken into account in any decision based on the review data. Persons who repeatedly abused the system would be restricted to read-only access. The new system, while it could perserve anonymity when necessary, would have a degree of openness not possessed by the present system.

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Many of the negative respondents to David Mermin's proposal to modernize physics communications don't seem to realize that most of what is needed is already being done on a regular basis, and with a user base substantially larger than the physics community. Questions about hardware, software, viruses, access or how to pay have already been answered by information services such as Compuserve. Indeed, this commercial information service provides a good model for most of our needs.

Compuserve regularly provides subscribers with information in the form of text and graphics. The information is divided into hundreds of categories, each overseen by one or more experts in that field. Information from other users is available either in the form of streams of short bulletin board messages or as archived library files that have been previously examined by one of these experts. The experts also regularly serve as moderators and information sources for the bulletin board.

Physics certainly has special needs, such as a permanent archive. We would also benefit from software and hardware standards that would allow the convenient use of equations and chalkboard graphics in the bulletin board messages.

Those physicists who are not regular users of a high-quality information service almost certainly underestimate the improvement that would result from such an overhaul of physics communications. For example, it is hard to exaggerate the importance of simply having a large number of experts accessing a common bulletin board on a regular basis. Electronically stored articles also greatly expand the document search and retrieval possibilities beyond anything offered by libraries.

My own opinion is that the rapid and public reaction to papers by various interested readers would quickly prove to be more effective than formal peer review. The resulting message stream (or a summary) could be associated with the paper. One would quickly learn to judge the value of an article by whether or not the authors were available to defend it and by how responsive they were to questions of methodology. For example, I doubt that the recent cold fusion fiasco would have lasted more than a day or two in the free-for-all of an interactive bulletin board. And it would have been good, clean fun!

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I would like to congratulate you for allowing David Mermin to publish "Publishing in Computopia"! Mermin introduces some radical ideas for a debate whose time has come.

I personally do not feel that there need be any paper grading system on Mermin's proposed bulletin board. I believe that the absence of a grading system will enhance our creativity. In my field of lasers, some exciting new developments—such as optical-Kerr-effect mode-locking and fiber lasers—are based in part on papers published 10–20 years ago, when their future importance was unsuspected by most.

Let the readers decide over a long period of time what is important. Citation journals will continue to give grant evaluators an objective measure of readers' interest.

I still would like you to publish PHYSICS TODAY, however. You have excellent contributors who help me tremendously in keeping up with the exciting new developments in physics and in related fields.

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Nuclear Recoil Spotted Spectrally

In his exciting account of prospects and progress in neutrino and dark matter detection with low-temperature detectors, Leo Stodolsky (August 1991, page 24) describes interesting manifestations of nuclear recoil observed with the use of thermistors.[1] Earlier, quantitative observations of nuclear recoil following radioactive decay actually exist, for which we thought it useful to give reference. In alpha-particle spectrum experiments started at CERN and the Institut d'Astrophysique Spatiale (Verrières-le-Buisson, France) in 1983, we placed a thin ^{224}Ra radioactive source opposite our (windowless) low-temperature calorimeter.[2] The radioactive decay chain gives rise to the initial alpha particles from ^{224}Ra and subsequent ones from ^{220}Rn, ^{216}Po, ^{212}Bi and ^{212}Po. After the emission of an alpha particle it was possible for the daughter to recoil in the direction of our detector and get embedded in it. The spectral line from the ^{224}Ra parent was single. Subsequent decays produced lines not only at the respective alpha-particle energies E_α but additional, satellite peaks shifted up by the recoil energy $(M_\alpha/M)E_\alpha$, where M_α and M are the masses of the alpha particle and of the alpha-emitting nucleus—in agreement with simple linear momentum conservation.[3] In our more recent work,[4] the alpha-energy resolution in the spectrum shown in figure 5 of reference 3 has been improved by approximately a factor of 4.

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