

The sentiment of the unity of physics

Our will to believe, in spite of strong arguments to the contrary, that our diverse activities are part of one noble effort lends historical meaning to our work and perhaps even helps to create unity.

Robert R. Wilson

We discuss the unity of physics with a kind of nostalgia, for our field today is so patently diverse. We hear this diversity in the cacophony of our meeting halls, in the differing languages of theorists and experimenters, of rheologists and astrophysicists. The sheer numbers of physicists and of the papers we publish—one every few minutes—overwhelm us. Diversity has even been institutionalized: Our American Physical Society is now organized into a dozen disparate divisions, and physicists have organized many physics societies outside APS. One would expect one of the clearest expressions of the unity of physics to lie in the teaching of physics, but even that enterprise has its separate American Association of Physics Teachers. And didn't we establish the American Institute of Physics, of which APS is but one of ten members, because of the need for unity in physics?

Diversity, diversity—it would be better for me to be discussing diversity, not unity. And yet I shall argue that all areas of physics have enough common content, enough common heritage, enough common understanding, enough common identification to justify

the sentiment, if not the actuality, of the unity of physics.

Let me emphasize the driving force of sentiment. We Americans are sentimental about Jefferson's dictum "All men are created equal." Yet from almost any point of view this statement is not true. It was even less true in Jefferson's time. But behind the sentiment lies a great truth, for the meaning and idealism behind the sentiment constitute much of the moral underpinning of our nation, and of the kind of nation we aspire to become.

Perhaps in a similar sense, we physicists find direction and cohesion and meaning in our own precious sentiment of the unity of physics. Perhaps we even create unity by that sentiment—just as the vision of our Founding Fathers helped to establish a level of equality that did not exist before.

International unity

Let me start my case for the unity of physics with one of its strongest aspects: internationalism. It is a cliché that science knows no boundaries between countries. There is no such thing as French electricity, German thermodynamics or Greek atoms. All of the physics journals are exchanged among countries, and by reading *Physics Abstracts* a person in any country can know of and send for any physics publication—at least in principle. In the Science and Technology Network International (described in the article on page 51) and Bitnet we now have

informal international computer networks to simplify the finding and exchange of information. Soviet and American textbooks have frequently been translated and used in both countries. A discovery in one country is celebrated in other countries and becomes a part of the great scientific edifice, a part of the common culture of humanity.

This tradition became a bureaucratic reality with the unity of units when the International Bureau of Weights and Measures was formed at French initiative in 1875 at Sèvres. The French government ceded land, which became international territory, to the bureau, which held an international conference every six years (now every three years). This step was most assuredly crucial for the unity of physics, at least in its international connotations, for we do follow the bureau's strictures very carefully and use the same units everywhere as a matter of course.

More recently, the International Union of Pure and Applied Physics¹ has sponsored and regularized international visits and conferences. This group gives an organizational foundation to the international unity of physics, just as the International Council of Scientific Unions, of which IUPAP is a part, does for science.

In my own field of particle physics an example of this same unity is the Centre Européen pour la Recherche Nucléaire, which is a triumph of European internationalism, indeed of world

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Unity. This old photograph shows the International Bureau of Weights and Measures, formed in 1875 at Sèvres, France. The bureau helped physicists establish worldwide unity of units. (Photo courtesy of US National Bureau of Standards.)

went to a relationship in which respected members of the scientific community represented us as the President's science adviser (see the news story on page 45), as members of the President's Science Advisory Committee or as members of the Atomic Energy Commission's General Advisory Committee. Today that kind of scientific representation is almost nonexistent.

What happened in APS during this period? Until the 1960s politics was outside the purview of the organization. We ran our meetings, we published our papers, period. However, as our representation in the halls of government declined, and as the disenchantment of younger members with the war in Vietnam increased, APS responded by forming the Panel on Public Affairs, the Forum on Physics and Society and the Committee on the International Freedom of Scientists. APS established these groups to provide informed opinion and a mechanism for a public voice for physicists. More recently APS opened its Office of Public Affairs in Washington, DC, to keep us abreast of developments there.

In 1983 the APS council released a statement on the terrible danger of nuclear weapons. The council also called on leaders of all governments to make great efforts to reduce the number of bombs and delivery systems. It called for a resumption of negotiations to prevent the spread of nuclear weapons into outer space, for the continuation of all existing arms-control agreements, including SALT II, and for "serious negotiations to ban the testing of nuclear weapons in all environments for all time as called for in the Non-proliferation Treaty." (See *PHYSICS TODAY*, March 1983, page 64.) Today some might think of this statement against sin and for motherhood as being almost

disloyal—yet the council has stood by it.

Now into our troubled midst the Strategic Defense Initiative has been injected. One part of the Administration has eloquently and very clearly enunciated that it is possible to develop an impermeable missile shield that will protect the general population and make nuclear weapons obsolete. Ah, would that it were so! Unfortunately, it is technically ridiculous. Most reputable physicists with experience in large technical projects agree that it is not feasible. Yet a few physicists of substance have spoken up for SDI. There is no unity of physics or of physicists where SDI is concerned.

The situation is exacerbated because, at the same time, we have the amazing spectacle of most of the technical people in the military and in the large defense laboratories maintaining that SDI won't protect the people but that it will be useful in protecting missile sites—as well it might. The latter goal is in contradiction to the former, the official, goal. The parallel between the official Strategic Defense Initiative and Stalin's adoption of Lysenko's genetics, which destroyed Soviet genetics and kept the Soviets from developing good grain seed, is frightening. Our President is in desperate need of qualified scientific advice.

Bureaucratic unity

If politically physics is in disarray, bureaucratically it is not. Here I have in mind two kinds of bureaucracy: government funding agencies such as NSF and DOE, and the APS bureaucracy.

There are dedicated and competent physicists in government who have chosen to make physics—all the kinds of physics—possible by working essentially as beneficent brokers between

those who need government funding for their research and the government agencies that administer the funds. These physicists are the *sine qua non* of nearly all the research now being done in US universities and national laboratories. Let's sing out in praise of these individuals, who do so much to help provide the wherewithal for a creative climate for physics!

The American Physical Society, our own bureaucracy, is a wonderful organization in that it has the tradition of being operated by its members for "the advancement and diffusion of the knowledge of physics." In part this has been possible because the American Institute of Physics was formed about 50 years ago with the same goal but also to carry out the more nitty-gritty affairs such as publishing the major physics journals in the US. It has been possible also because Bill Havens and a small but dedicated staff in APS's New York City headquarters have kept that tradition alive in spite of our growing size. Members of APS have also given generously of their time, serving as elected officers, as council and committee members and as editors of our journals. The unity of physics is nowhere more evident than at a typical council meeting, where it is difficult to recognize to which division a particular member belongs. Scratch a physicist, and you find—a physicist! Unity? Yes.

All praise for Bill Havens and his crew, for David Lazarus and his editors too.

In *PHYSICS TODAY* we find perhaps the most visible expression of the unity of physics. This AIP publication reaches out to all 85 000 members of the ten scientific societies that belong to AIP (see the listing on page 4). Through its varied articles we keep up with all of our fields, and through its editorials and news columns we keep in touch with one another.

Gloria Lubkin, *salut*, and remember your continuing responsibility to keep the flame of unity of physics burning brightly.

Unification

Any physicist at this point is going to complain that I have neglected the most basic unity of physics, unification itself. (Perhaps I have avoided unification because Leon Lederman has already so eloquently and perceptively

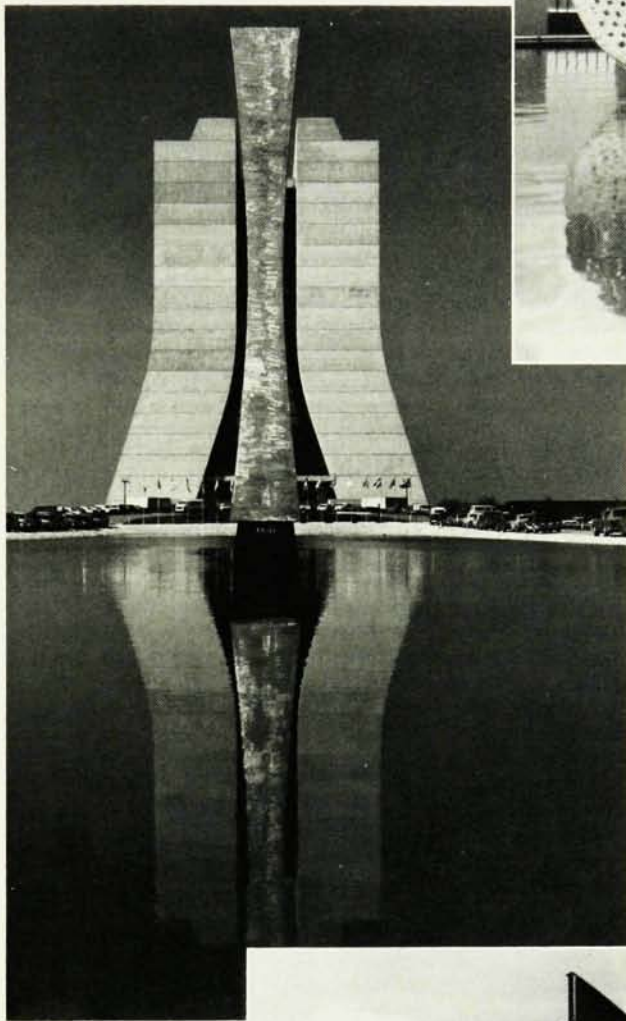
Sculptures by the author at Fermilab, each signifying unity in some way. (Fermilab photographs.)

discussed² it in his 1986 Richtmyer Lecture, entitled "Unification, grand unification and the unity of physics.") Now next to discovering new knowledge, unifying knowledge into the fewest concepts and the simplest but most complete theory is what each of us, in his or her fashion, tries to do. Perhaps just that approach is enough to justify the claim of the unity of physics. I would prefer to consider such a basic activity as characteristic of the unity of science.

We particle physicists tend to arrogate to the term "unification" only our own narrow usage, thinking of the sort of thing Maxwell did in unifying electric and magnetic phenomena, or of what Einstein sought to do by including gravitational forces. And we celebrate the success more recently of Sheldon Glashow, Salam and Steven Weinberg in unifying weak and electric forces.

There is no question but that particle physicists, because of the successes of the electroweak theory and quantum chromodynamics, have their blood up. Both experimenters and theorists want to push further toward a super unification. Super experimenters want to construct super colliders to take a super-Higgsean step forward. Super theorists want to construct super theories of supersymmetries or superstrings to explain everything. This is no joking matter, for all are dead serious about these next steps toward the foundations of physics. In a different sense we may also have in all this excitement a test of the unity of physicists.

There must be few physicists, if any, who have not thrilled to the drama, the fortune, almost the miracle of the astronomers and physicists who have found unity among their subjects in the first tiny fraction of a microsecond of the exploding universe. If so, then I would hope that the unity of physics among divisions of APS is real enough that physicists from all disciplines would be sensitive to and identify with the intellectual curiosity that feeds the enthusiasm of particle physicists for the Superconducting Super Collider. However, the expense projected for SSC—several billions of dollars—is not trivial. Physicists in other fields may fear that their funds could be jeopardized if SSC is pursued in this time of shrinking financial support of science. Researchers in other divisions have





CERN, near Geneva, Switzerland. The irregular dashed line is the French-Swiss border. This research facility promotes international unity by bringing together physicists from many countries. The Joint Institute for Nuclear Research, at Dubna, in the Soviet Union, serves a similar function for scientists in Warsaw Pact countries. (CERN photograph.)

their own agendas; their research is equally fascinating and fundamental, and may be even more relevant than SSC would be to our ability as a nation to remain technologically competitive with other nations.

Through its Panel on Public Affairs, APS did try to address the question of how relative priorities among subfields might be set, and *PHYSICS TODAY* dedicated an issue (March 1985) to expositions of research in various fields. Also, over the past couple of years several APS divisions have arranged symposia to acquaint physicists with work at major research facilities in the various subfields of physics. It was a good effort, which unfortunately petered out, but Chuck Hebel, past chairman of POPA, was able to conclude that, yes, we should try to fund outstanding projects while maintaining a balance in funding among all subfields.

Personally, as a member of the particles and fields community, I feel that it is our business to push hard for funds for SSC, just as it is the business of colleagues in other divisions to push equally hard for their funding. After all, this is American *laissez faire*. The measure of unity in physics will be the degree to which we realize that there is no absolute limit on the total amount of funding, that the total amount going to physics is very small compared with what physics can do for our country and our culture. The measure will also be how well we pursue our separate aims without embittering our internal relationships—our unity of physics.

Unification is becoming almost serious enough that it bears a bit of watching—from a strictly occupational point of view. I suppose thousands of physicists, perhaps all, secretly fantasize stumbling upon the ultimate theory of everything. This is not completely unreasonable, for it is almost a religious precept of science that the solution to a problem is most likely to come by indirection.

Just suppose, even though it is probably a logical impossibility, that some smart aleck came up with a simple, self-evident, closed theory of everything. I—and so many others—have

had a perfectly wonderful life pursuing the will-o'-the-wisp of unification. I have dreamed of my children, their children and their children's children all having this same beautiful experience.

All that would end.

APS membership would drop precipitously. Fellow members, could we afford this catastrophe? We must prepare a crisis-management plan for this eventuality, however remote. First we must voice a hearty denial. Then we should ostracize the culprit and hold up for years any publication by the use of our well-practiced referees. Just to be safe, we should put the paper on our *Index*—I mean in our index—where it can be lost for centuries. Then too, our high-tech bonfires will make an auto-da-fé seem like a Turkish bath. Unification researchers, be warned! Hell hath no fury like a physicist overly unified.

Aesthetic and creative unity

Apart from the content of physics—or because of its content—the joyousness of physics is one of its principal unities. The pure fun of it is a delight that seems to attach to all physics endeavors—just watch physicists doing what they do. Victor Weisskopf and S. Chandrasekhar have both written in these pages about the importance of beauty in the creation of physics (see *PHYSICS TODAY*, June 1976, page 23, and July 1979, page 25). The ecstasy of the creative process is a universal experience among physicists and is not a whit different from that felt by artists and poets.

Chandrasekhar's quotation from Henri Poincaré seems only slightly to overstate our delight:

The Scientist does not study nature because it is useful to do so. He studies it because he takes pleasure in it; and he takes pleasure in it because it is beautiful. If nature were not beautiful, it would not be worth knowing and life would not be worth living. . . . I mean the intimate beauty which comes from the harmonious order of its parts and which a pure

intelligence can grasp.

Poincaré may have been carried away by his romantic rhetoric, but it exemplifies what most physicists mean by "the unity of physics." They are referring to the whole living fabric of physics—a glorious evolving creation that, like any great art, has significance and deep meaning. As students we become familiar with the different interwoven designs of the tapestry; we become aware of the warp of its mathematical content and the woof of its perceptual content. We use it, we add to it. In unification we connect different threads, embellish here, simplify there, always seeking a grand pattern. The fabric interweaves with other sciences, with philosophy, with technology, eventually with the whole of human knowledge—a unity with the whole.

Without exhausting the subject of the unity of physics in any way, I have examined some of the "varieties of 'unifious' experience," to borrow from William James. The argument against the unity of physics is strong, but the sentiment, the will to believe in it, is almost overpowering.

Sentiment? Will to believe? Is this just superstition, a subjective caprice? It is clearly a state of mind, and we physicists are not supposed to think that way. Perhaps the story, no doubt apocryphal, about Niels Bohr and the horseshoe he had nailed up over the door of his summer house is appropriate. A visitor reprimanded him severely: "Surely, Professor Bohr, you of all people do not believe in that superstitious claptrap that the horseshoe will bring you good luck." "Certainly not," replied Bohr indignantly, "but they say that it works just as well even if you don't believe it."

Perhaps in that sense, but more in the sense of Jefferson's dream of perfect equality, we need to cultivate the unity of physics; it makes us one with our progenitors, one with our living colleagues, one with those who will create the future physics.

References

1. For a history of IUPAP see P. Fleury in *Physics 50 Years Later*, Natl. Acad. Sci., Washington, DC (1973).
2. L. Lederman, *Am. J. Phys.* **54**, 594 (1986). For a very learned and philosophical article on "The unity of physics," see E. Amaldi in *Physics 50 Years Later*, Natl. Acad. Sci., Washington, DC (1973). □