letters

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physics baccalaureates from colleges of arts and sciences unrelated to engineering schools.

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Help wanted

The purpose of this letter is to request information regarding the relationship between a concept frequently called *duality* in lumped-constant physics and the continuum formulations of physical laws. The underlying motive to the query is to determine whether there is a more symmetrical formulation of Maxwell's equations than the traditional ones. More specifically: Can Maxwell's equations be formulated in such a way that there are no blanks that tempt one to insert magnetic charge and current? This question was recently addressed to the Forum section of the IEEE *Spectrum*. A handful of responses was received, none of which were satisfying. With a world-wide readership, this is surprising.

First, the meaning of the term "duality," in the present context, must be explained. In lumped-constant circuit theory there is a transformation that may be performed on circuits, equations and statements, which we will refer to as the *dual transform*. This transform is its own inverse. A partial listing of dual-transform pairs is given in the table. The transform has the property that, if a statement is valid for a given circuit, then the dual of that statement is true for the dual circuit. Another property is that the five laws of circuit theory (Kirchhoff's current and voltage laws plus the V–i terminal relations for inductance, resistance and capacitance) transform into themselves, but in a different order.

The same principle obtains in lumped-constant mechanics. Here, Kirchhoff's laws are replaced by "Newton's force and velocity" laws. The former says that the sum of forces (including inertial forces) into a mechanical node is zero. The latter says that the sum of relative velocities between "terminals"of mechanical components around any closed path is zero. The terminal relations for L, R and C are replaced by those for mass, dashpot and spring. These five relations also transform into themselves, but in a different order.

The following two equations are Kirchhoff's laws in point form.

$$\nabla \times \mathbf{E} + \frac{\partial \mathbf{B}}{\partial t} = 0 \qquad \text{(KVL)}$$

$$\nabla \cdot \mathbf{J} + \frac{\partial \rho}{\partial t} = 0 \qquad \text{(KCL)}$$

They strongly suggest that they are dual-transform pairs. But the remaining two equations are not obvious.

The basic question is: Is there a way to formulate the laws of continuum electrodynamics and/or mechanics in such a way that the dual transform changes them into themselves? If so, what are the continuum transform pairs? More generally, can dual symmetry replace the traditional asymmetry?

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Dual-transform pairs

voltage, v	current, i
inductance, L	capacitance, C
resistance, R	conductance, G
charge, Q	flux linkage, λ
Kirchhoff's voltage law, KVL	Kirchhoff's current law, KCL
mesh	node
series connection	parallel connection
short circuit	open circuit
reference node	outer mesh
cut set	tie set
tree branch	link
mass, M	spring compliance, K
damping constant, D	(damping constant)$^{-1}$, D^{-1}
force, f	velocity, u
Newton's force law, NFL	Newton's velocity law, NVL

Practical vs. real physics

In the recent past, due to the fine studies of Lee Grodzins and others, our profession has finally acknowledged that career opportunities in academia and "pure" research may indeed be finite. There is much talk about the necessity of revising curricula, both undergraduate and graduate, to prepare our students for a future in applied research and development. Prestigious committees on education and manpower have called for new courses and facilities for better preparation of a new generation of students to man the applied societal needs of the future.

Yet all these founder at their inception because of the zero-population growth status of physics faculties: There simply is no new money available to hire the new faculty to staff new programs. We seem to be hell-bent on ensuring our own demise. There *is* another way, but one which I have never seen articulated, and one which would cost essentially nothing. We should, in plain and simple words, "put our money where our mouth is"! We should *legitimize* "practical" physics by bringing the living, on-campus, examples of it *inside* the physics departments. Why, for example, are solid-state physicists largely outside the physics faculties at Harvard, Yale, Princeton, Stanford and Caltech? How can their resident physics students even meet the "applied" physicists as instructors in required physics courses or as TA supervisors in elementary courses? How can we expect some of the best of these students to aspire to careers in "practical" physics when most of the actual practitioners who could serve as role models are invisible, housed in limbo in some other department down the street?

Some departments, happily, have not opted for such segregation. As examples, Cornell and my own department have co-mingled solid-staters and other "practical" types with "real" physicists for so long that even the faculty cannot tell the difference. No one in Urbana is ashamed to have John Bardeen as a colleague! I believe other departments could do likewise, returning their distinguished, on-campus, "practical" physicists to the fold simply by a bookkeeping feat: eliminating the extraneous "departments," "programs," and "operations" which have placed such individuals in limbo and letting them take their place as living, breathing *physicists*, with no special adjectives, as an integral part of the physics-department faculties. Such a change would involve no new funds or staff positions. We might even save a few dollars by eliminating the need for different kinds of letterhead stationery! Most important, we would thereby acknowledge that practical physics *is* physics, and is worth the serious study and effort of our best students.

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Large Space Telescope

We read with interest your editorial in the April issue (page 96) supporting an increase in funding for nuclear energy research and the development of a Large Space Telescope by NASA.

NASA recommended to the Office of

Management and Budget $12.0 million for the initiation of the Large Space Telescope program in the fiscal year 1977 budget. The OMB deleted this money from the request submitted to Congress. The Committee on Science and Technology restored the LST program to the NASA budget in reporting out H.R. 12453, the NASA authorization for FY 1977.

The Senate has adopted the position of the Administration, which does not include the Large Space Telescope. Therefore, when the House and Senate authorizing Committees met to resolve differences in the NASA budget the Large Space Telescope was supported by the House Committee. The Appropriations Committees of the two Houses have yet to act on the NASA budget.

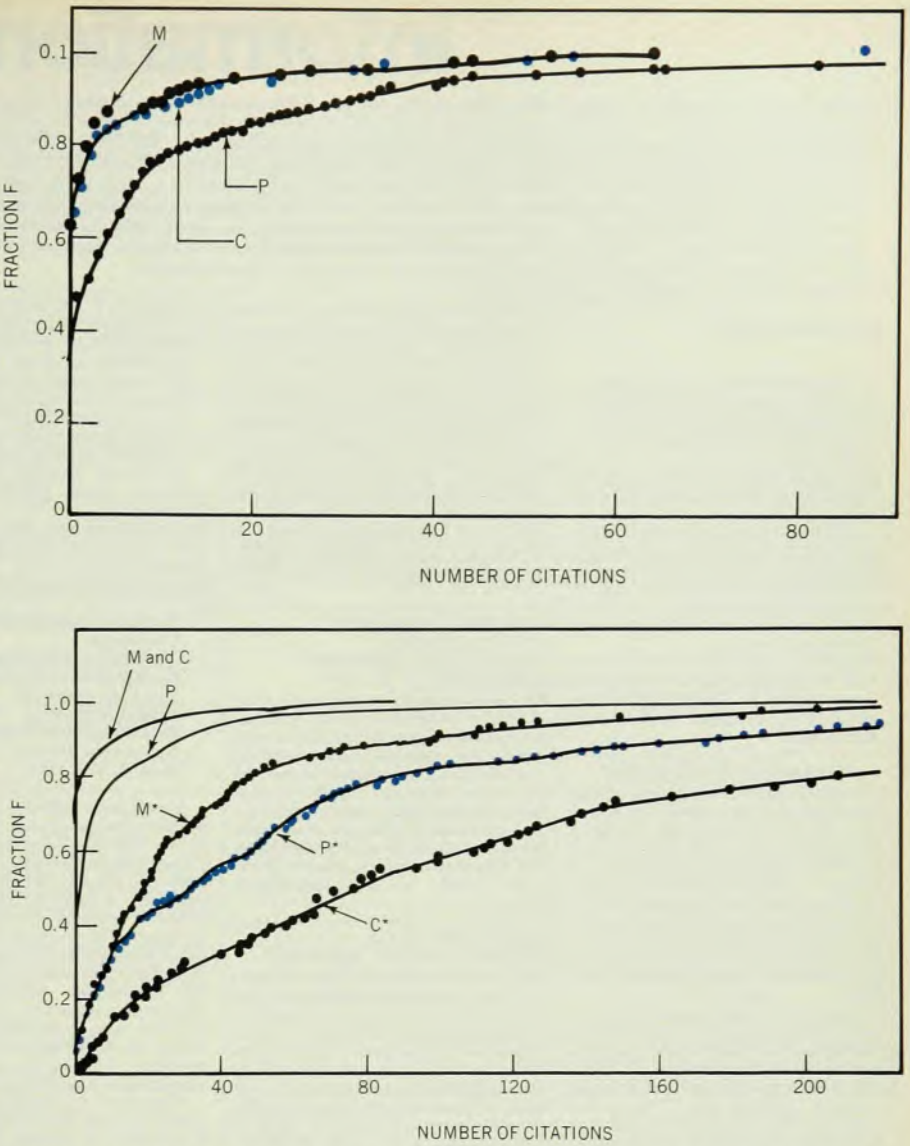
We have recounted this history of the current budget since there is evidently some confusion as to the support for the Large Space Telescope program. We also wish to encourage members of the Institute's member societies to give their full support to a broadened space science program in the years ahead.

DON FUQUA
Chairman, Subcommittee on Space Science and Applications
Committee on Science and Technology
LARRY WINN
Ranking Minority Member
Committee on Science and Technology
US House of Representatives

Citation Index misleading

The Science Citation Index catalogs the references in articles (in the examined source journals) by listing the source article under each of the references which it contains, the references being sorted alphabetically by the last name of the first author on the reference. A number of articles[1] have pointed out pitfalls in the use of SCI and, in some cases, inveighed against its use in view of its well-documented idiosyncracies. But reports and rumors of its use in the Federal government and elsewhere abound. We point out here another *caveat*, namely the different norms[2] between professions and within professions.

We used the 1971 edition of SCI, which included over 2200 source journals and over 4.3 million citations from source journal items. We chose two populations each from the fields of chemistry, mathematics and physics. The first sample was chosen, respectively, from the corresponding professional society: The American Chemical Society; the Mathematical Association of America and the Society for Industrial and Applied Mathematics; and The American Physical Society. In each case, the sample was chosen at random, but was uniformly distributed with respect to alphabet. The second sample consisted of the full professors of the corresponding faculties of the first five schools in each field as ranked by K. D. Roose and C. J. Anderson (*Chemistry:* Harvard, Cal. Tech., U. Cal., Berkeley, Stanford, MIT; *Mathematics:* U. Cal., Berkeley, Harvard, Princeton, Chicago, MIT; *Physics:* Harvard, Cal. Tech., U. Cal., Berkeley, Princeton, MIT). For each member of all of these samples we went through SCI and counted the number of citations he received in the 1971 edition. The figure presents the data in a normalized, integral fashion.



Normalized integral distribution of society samples (above) and university samples (below). *F* is the fraction of the sample having fewer than the corresponding number of citations in the 1971 Science Citation Index for samples from the mathematics (M), chemistry (C) and physics (P) professional societies.

One could well put forward a number of possible explanations of these differences, but what is indicated to us is the need for much more thorough-going studies of the parameters of professions, considering not just citations and not just these scientific professions. Only such thorough-going studies will begin to give us some appreciation of career patterns in the various professions.

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References

1. Science Citation Index **5**, pp. 65–69; Inst. for Scientific Information, Inc., Philadelphia, 1974).
2. N. Kaplan, Amer. Documentation **16** 179 (1965); J. R. Cole, S. Cole, *Social Stratification in Science*, (Univ. of Chicago Press, Chicago, 1973).
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