proved. First, reduce the time between proposal and contract award, even at the risk that a "second best" contract slips through occasionally. Second, adapt the frequency of progress reports to the type and size of the project and do not insist on significant progress in each period. Third, make research goals as flexible as possible and eliminate milestones altogether.

ALFRED SOMMER
Wellesley, Massachusetts

Sex-linked ability

In my physical science classes one of the major objectives is to help nonscience majors understand the nature of science and how the laws of science are induced. In working toward this objective I stress that there are very few "facts" in science, but rather, that scientists base their inferences on the statistical evidence available at the time.

While agreeing heartily with virtually all of Jewel Plummer Cobb's recommendations for ways to encourage young women to consider careers in science, I was surprised by her statement in August (page 72) which said, "—women scientists and mothers should stress the fact that proficiency in mathematics is not a sex-linked characteristic." Was the word "fact" one of Cobb's own choosing or was PHYSICS TODAY paraphrasing her message at the January APS–AAPT meeting in New York?

If Cobb has sufficient statistical evidence to claim that proficiency in mathematics is not sex-linked as a fact, I would very much appreciate learning about that evidence. Although I don't believe the research I'm familiar with is conclusive, the preponderance of it suggests that mathematics ability may be sex-linked when considered statistically.

Just because our sense of fair play urges us to want to believe that proficiency in mathematics is not sex-linked, we should not claim this ideal as a "fact" or assumption which is never to be questioned. If an evaluative instrument of aptitude for mathematics having generally accepted validity were administered to a large randomly selected sample of young men and women, I have no doubt that certain females would score higher than 95% of the males. Certainly these, and many other mathematically gifted young women, should be encouraged to consider careers in the physical sciences. It would also be useful to carefully scrutinize the mean and deviation scores of the male and female students on an accepted valid instrument administered under tightly controlled experimental conditions. After applying appropriate statistical treatment to the data we may be able to tentatively infer the existence of a relation with sex in the sample or the lack of such a relationship. Drawing such an inference is different from claiming an idea to be a scientific "fact," however.

HAROLD L. CRATER
The University of Mississippi
University, Mississippi

Dean Cobb replies: My statement is made following a study of the literature citing various scientific studies that confirm the absence of clear differences in ability between boys and girls in elementary school. There are national studies to confirm that, up to nine years of age, boys and girls score equally in mathematics tests. If the ability to do math is sex-linked, it would show itself in this age group. There is a paper by Richard Stafford which is most controversial. It has received little acceptance. Most studies indicate that cultural and environmental influences are responsible for any differences noted in older males and females, rather than biological differences that are "intrinsic." As a biologist I am very uncomfortable with the fuzzy data that attributes human intelligence performance in adolescent and post adolescent subjects to genetic causes. The level of clear and sophisticated research is not yet available. If you will read my recent paper "Filters for Women in Science" in the *Annals of the New York Academy of Sciences,* you would be enlightened.

JEWEL PLUMMER COBB
Rutgers, The State University of New Jersey
New Brunswick, New Jersey

More on free-electron lasers

In July your news story entitled "Update on free-electron lasers and applications" gives credit to "Henry" Motz for building the "undulator" with reference to my *Journal of Applied Physics* paper of 1951. I was very pleased to see this, but it is unfortunate that my name is not Henry but Hans. At the same time I would like to comment on the explanations given of the device. It is, of course, not wrong to use atomic physics concepts, because quantum phenomena are underlying the purely classical laws of physics—which are sufficient for the theoretical description, except perhaps in the x-ray region. My idea of the amplification process was inspired by R. Kompfner's traveling-wave tube, where the helix slows down the wave so that it can be in near synchronism with the electron beam. It occurred to me that near synchronism could also be achieved[1] by making the electrons undergo a periodically deflected path. A recent analysis by Norman Kroll[2] elaborates my theory in an admirable way. In a recent paper[3] I pointed out that there are essential differences between the operation of a laser

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and that of the so called "free-electron laser." The laser relies on a population inversion created by a pump but the "free-electron laser" produces synchronously emitted synchrotron radiation by tuning the light frequency to achieve synchronism with electrons of an "inverted" part of the electron-beam energy distribution.

References

1. H. Motz, M. Nakamura, "Fast wave amplification in Symposium on Millimeter Waves," Brooklyn Polytechnic (1959).
2. N. Kroll, *Novel Sources of Coherent Radiation*, Addison Wesley, (1978), page 115.
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HANS MOTZ
University of Oxford
Oxford, UK

8/14/79

Neutrino paradox

There is an apparent consequence of neutrino physics that introduces the spectre of a paradox (at least to me). The articles I've studied tell about prodigious production rates in stellar interiors and various atomic reactions; about how the interaction cross section allows neutrinos to zip through a light year of lead like a hot awl through a pat of oleo, and about the sleuthful, imaginative experiments that have been performed to perceive them.

A most interesting entity, this elusive particle of Wolfgang's.

I am beset, however, by a question that begs understanding.

If neutrino generators are as prolific as is theorized, and if neutrino interaction with matter is the ultimate paranoia as is evidenced by experiment, then, if one assumes time-independent (on a universal scale) creation rates, why is it that present background population from all sources, since time immemorial, is not overwhelming? After all, the universe is not lead or chlorine-37. What, I ask, is the mechanism that negates the existence of an Olbers's Paradox for neutrinos?

Do they age? Is there an unknown absorption mechanism in interstellar space? Or perhaps, do Stephen Hawking's mini-black holes gobble 'em up?

With assumed license, my tongue in cheek, and a wee touch of assertiveness, especially since there be no negation precedence (of which I am aware), I propose Mohler's Paradox to the more nimble minds about me.

SAILOR H. MOHLER
Columbia, Maryland

We asked John Bahcall of the Institute for Advanced Studies to comment on Sailor Mohler's letter. He agrees that there is indeed an Olbers's Paradox for neutrinos, just as there is for photons. Both apparent paradoxes, have the same resolution—namely the red shift resulting from the expansion of the Universe. The more distant a source of photons or neutrinos, the more these are Doppler shifted to lower energies.

EDITOR

Physicists and energy problem

I think that it is time for The American Physical Society and the American Institute of Physics to re-publicize and reinforce their 1975 study of *The Efficient Use of Energy*. It could profitably be updated, especially with respect to the costs of energy, as well, although the basic conclusions stand now as they did then.

In the year the study was published, I, a physicist, began to teach the energy-related subjects in the School of Architecture at California Polytechnic State University, San Luis Obispo, which is the largest school of architecture in this country. First, I want to emphasize the study's strong recommendation of the disciplines of classical physics, and to point out that there is, in the British Commonwealth, a specific discipline of the applied sciences with respect to architecture: architectural science. I educated myself first with a bachelor's degree in physics, second with a long tour in a defense laboratory, third by attending a good school of architecture for two years, and fourth by taking the Master of Architectural Science at the University of Sydney. Departments of physics in this country—especially those in universities having schools of architecture—could very profitably institute master's programs in architectural science. The program at Sydney, which is a world-class university in many fields, was developed under the far-sighted leadership of Henry J. Cowan. Frankly, "modern physics" always has seemed hopelessly muddled to me, aside from the junctures effected with the classical disciplines by Einstein, de Broglie, and Gabor; no student ought to be permitted to study quantum mechanics until he has mastered acoustics, which scarcely is taught nowadays!

My point is that we seem to be drawing farther and farther away from the efficient, let alone intelligent, use of energy. Recently, I testified before my city's council on the subject of its vaunted "energy policy." Our late mayor, who at the time had been tapped as Secretary of Transportation, took umbrage when I introduced the findings of the APS study, partly, as he said, because he didn't understand technical matters, and partly, undoubtedly, because he had conceived the policy as a mandatory insulation program for home-owners; the chief beneficiaries of the policy would be the electric utilities, who could substantially shave their peak loads, which in this region are due to electric space heating of homes. Any attempt to do this more directly, by restricting space heating with electricity, was rejected as "politically unacceptable" by the policy's coordinator. The policy had been studied and developed for more than a year by a very large committee, yet my introduction of the APS study came as a complete novelty to all those concerned with it.

Are physicists really having any effect on energy consumption? If not, why? There is evidence that "quality of life" only marginally increases when the installed electric capacity of a society exceeds 2 kW per capita; in this region the figure is nearly 5 kW per capita, and those who govern are clamoring for more. Here we have extinguished the most concentrated food resource in the world, the Columbia River's salmon runs, in our quest for electric power; we could restore a substantial fraction of the runs by removing the first four dams on the river (or reducing their operating heads) at the cost of 10% to 15% of the installed capacity. Yet the Corps of Engineers is aggressively expanding its hydropower program. The aluminum industry uses 21% of our electric power, yet provides only 0.5% of our employment; the cost of a large commercial airplane would increase only by a few percent if electric power were charged at its present replacement value, yet we subsidize the manufacture of energy-wasting aluminum window-frames by suppressing real costs. And so, *ad infinitum*.

Aden Meinel, past president of the Optical Society, who together with his wife, Marjorie, kept the idea of solar energy alive when it was extremely unfashionable, used to start his lectures with a gigantic projection of the Sun, saying "Nature long ago discovered the correct scale and distance for thermonuclear fusion." We physicists have the knowledge to contribute a great deal to this, the critical problem of our times. It is evident that we need much more than mere knowledge to influence policy effectively.

One can do no more than quote the finest "politician" this country has yet produced: "We must disenthrall ourselves, and then we shall save our country."

JAMES B. LEE
Portland, Oregon

Science policy

I read in the August (page 72) that Lewis Branscomb, APS President, was greeted with "gales of laughter" at a science-policy meeting at New York University when he set forth his ten "outrageous proposals"