LETTERS

'Computing in Physics' Prompts Model Debate

In "Computing in Physics: Are We Taking It Too Seriously? Or Not Seriously Enough?" (PHYSICS TODAY, July, page 11), James Langer expresses reservations about "numerical simulation" as it is now evolving as a consequence of the availability of ever-faster computers. He makes one statement in particular that requires scrutiny and discussion: "It is easy to build models on computers and watch what they do, but it is often unjustified to claim that we've learned anything from such exercises."

The first part of that sentence is incorrect in the sense that generally it is not easy to build models and then compute accurate solutions to the model equations. In fact, the numerical analysis and the associated programming often test the limits of what we can do, even with the fastest computers. For example, if we consider the Euler equations as a kind of mathematical model for computational fluid dynamics, we know from experience that this system of five highly nonlinear partial differential equations (PDEs) in three dimensions and time generally requires every computational technique, as well as computer capability, that we can bring to bear on the problem to arrive at a solution with acceptable accuracy in a reasonable computing time. As another example, take the Einstein field equations of general relativity, which are a complicated set of ten elliptic–hyperbolic PDEs that take us to the limit of what we can do computationally. Thus, the solution of mathematical models generally is not easy; of course, there are exceptions, but the numerical analysis of mathematical models is not a routine procedure.

Perhaps more to the point, the second half of Langer's statement is also not correct. Prior to the availability of high-speed computers, about all we could do with mathematical models like the Euler and Einstein equations was to develop special-case solutions that gave us some hint of what we could learn from the equations, and how those special cases compared with experimental data—for example, the Poiseuille flow solution of the Euler equations, and the Schwarzschild and perihelion advance solutions of the Einstein equations. In a few, relatively rare cases, we have been able to obtain analytical solutions to nonlinear PDEs, but generally for only a single PDE (with one real or complex dependent variable). Examples include the cubic Schrödinger equation and the Korteweg–de Vries equation. Moreover, solving even these rather modest problems has been considered a major breakthrough; consider, for example, the discovery of solitons.

Back in the precomputer era, more-complicated PDE problems stymied us, but the spectrum of problems we have since been able to investigate has grown steadily with the availability of computers of ever-increasing speed and capacity. Also, with this opportunity to generate numerical solutions, we have been able to gain insights into the properties of the model equation solutions that were completely unavailable previously. Thus, with respect to Langer's assertion that "it is often unjustified to claim that we've learned anything from such exercises," exactly the opposite is true; that is, only through numerical methods applied to mathematical models using high-speed computers have we been able to unlock the significant, often profound, features of the model equations, which otherwise would remain undiscovered or unconfirmed. We have also established an enhanced link between theory and experiment, since we can now compare the solutions to complex mathematical models with experiments that elucidate special phenomena addressed by the models. The experiments and models are no longer limited by the analytical solutions that might be available, and we no longer have to try to make do with low-order models (at most, one or a few equations). Nowadays, in contrast, we can include the full nonlinear effects in the models that we think might be relevant for explaining the experimental data.

To summarize, in contradiction to Langer's assertions, computer-based studies of mathematical models must be done carefully to control errors inherent in approximate numerical algorithms (generally not a trivial task). New insights typically result that would not be available from any other form of analysis. Such studies, therefore, can lead to significant advances in our understanding of physics and physical systems.

WILLIAM E. SCHIESSER
(wes1@lehigh.edu)
Lehigh University
Bethlehem, Pennsylvania

LANGER REPLIES: William Schiesser is absolutely correct about the importance of computing in the analysis of models such as the Euler equation for hydrodynamics or Einstein's equations for general relativity. I did not mean to imply that such work is "easy," or that we don't learn much from it. On the contrary, I was striving to make it clear that the computer has revolutionized the way in which we do research, and I said as much in the paragraph just preceding the sentence to which Schiesser objects. I then went on to remark, "In the 1960s, when our physics produced . . . a nonlinear differential equation that we could not solve analytically, we usually had to drop the problem. A decade later, with faster and more easily accessible computers, we had broken the numerical barrier and whole new areas of investigation had emerged." If I understand Schiesser, that's precisely the gist of his argument.

My purpose in the "Reference Frame" essay was to go further and argue that scientific computing is becoming an essential research tool for physicists in ways that may not yet be well accepted in US academic physics departments. I was thinking primarily about molecular dynamics simulations or large-scale lattice models, but I could have used continuum hydrodynamics to illustrate the same points. For example, there has been remarkable progress in developing codes for predicting hydrodynamic flows in complex situations, but there remains great uncertainty in cases involving strong turbulence. It seems likely, but not certain, that the Navier-Stokes equation (not the

continued on page 79

Letters submitted for publication should be sent to Letters, PHYSICS TODAY, American Center for Physics, One Physics Ellipse, College Park, MD 20740-3843, or by e-mail to ptletter@aip.org (using your surname as "Subject"). Please include your affiliation, mailing address, and daytime phone number. We reserve the right to edit letters.

Euler equation) contains all the physics needed for understanding turbulence. But we don't yet fully understand how very small fluctuations may be amplified to produce chaotic behavior. My point was that scientific computation is likely to play as big a role in solving this problem as will laboratory experiment and analytic theory. I think Schiesser would agree.

James S. Langer
University of California, Santa Barbara

'Entropy Engine' Fuels Discussion of *PT* Ad Policies

I note with disappointment a full-page advertisement in your September issue (page 77) from a company attempting to promote a so-called entropy engine that, if it worked, would grossly violate the second law of thermodynamics. Specifically, this company is promoting the notion that by means of simply rotating a cylinder and piston containing an ideal gas, useful work can be extracted from the gas, and its temperature thereby decreased. To make matters worse, the ad cites reputable works from the physics literature that, of course, contain no such nonsensical assertions.

So what is the harm of publishing such ads, you may ask? Well, despite the efforts of the physics community, most of the people in this world are not particularly well schooled in physics. According to the Web page of this particular advertiser, you can buy one of these entropy engines for $75 000. The device supposedly converts atmospheric heat into work, and (so the Web page alleges) it operates with an efficiency that "is greater than Carnot's." To any physicist, of course, that sends up a red flag that this product is not very likely to deliver on its promises. But will the average businessperson know that?

I do not ask that PHYSICS TODAY hold its advertisers to the same standards that apply to technical articles. However, when pseudoscientific nonsense such as this appears in the magazine, even if only as an ad, such products gain credibility that they definitely do not deserve.

Refusal to carry ads for products that are obviously contrary to the goals of an organization is a recognized and appropriate practice. For example, medical journals do not normally accept ads for tobacco products. Surely the evidence that supports the second law of thermodynamics is even more persuasive than that which links tobacco to ill health.

In the future, please refuse to run ads that are so blatantly erroneous or attempt to mislead or take advantage of those who lack a basic knowledge of physics.

Robert A. Koslover
(rkoslover@sara.com)
Scientific Applications & Research Associates, Inc
Huntington Beach, California

The Entropy Systems, Inc advertisement basically claims that the company's "entropy engine" is a perpetual-motion machine. Further investigations of the company's Web site show that this is exactly what it is trying to sell.

For a complete review of the company's claims, I recommend reading the discussion available on the Web from the sci.energy.hydrogen newsgroup. A summary can be found at http://x43.deja.com/getdoc.xp?AN=525477756&search=thread&CONTEXT=93752.

A publication that supposedly reports on physics should not print ads for pseudoscientific products that violate the laws of physics.

Jason Zweiback
(zweiback1@llnl.gov)
Lawrence Livermore National Laboratory
Livermore, California

BRODSKY REPLIES: On rare occasions, some members of the physics community question certain advertisements accepted by PHYSICS TODAY and other American Institute of Physics (AIP) publications. While we pride ourselves on the scientific integrity and usefulness of our editorial content, we generally have a relatively open policy on ads. Even so, we do reserve—and occasionally exercise—the right to reject ads. Several other leading scientific publications follow similar guidelines, and some of them accepted the same ad being questioned here.

Such decisions are hard to make, and clearly they fall within the purview of each publishing entity. It is worth noting that, in the case of AIP, some of the member societies have a policy that allows any member to give an oral presentation at a society meeting, along with the right to publish an abstract, no matter how questionable the thesis. Ads in AIP publications are a somewhat different matter, though, and drawing the line on what is acceptable is a more complex and difficult proposition.

AIP and its advisory bodies are currently reviewing the institute's guidelines. As AIP's executive director, I welcome written correspondence that will help us in our deliberations. It should be sent directly to me for forwarding.

Marc H. Brodsky
American Institute of Physics
College Park, Maryland

Book on Future of Science Leads to Energetic Exchange

Although I agree with virtually all of Joel Primack's criticisms and comments regarding John Maddox's highly opinionated work, *What Remains To Be Discovered: Mapping the Secrets of the Universe, the Origins of Life, and the Future of the Human Race* (PHYSICS TODAY, August, page 64), the doctor should heal himself first. In the process of correcting what he perceives to be Maddox's false statements, Primack states that "the energy of relativistic particles is not gravitationally equivalent to mass." Well, last I heard, positive energy of every known type falls into the right-hand-side gravitating source term of the Einstein equations. It is the energy imparted to relativistic particles that is responsible for creating new particles—that is, matter (as, for example, in accelerators). Matter gravitates. End of story.

Harry I. Ringermacher
(ringerha@crd.ge.com)
General Electric Corp R&D Center
Schenectady, New York

PRIMACK REPLIES: I am sorry that the statement in my review that Harry Ringermacher questions was not sufficiently clear. What I meant was that the gravitational effects of relativistic particles are due not only to their energy, but also to the other contributions that they make to the energy-momentum tensor $T^{\mu\nu}$. For example, for a gas in its rest frame, T^{00} is the energy density ρ and the space components T^{ii} equal the pressure P. For the scale factor of the universe R, Einstein's field equations imply that the deceleration $-\ddot{R}$ is proportional to $(\rho/3 + P)$. Thus, in the case of highly relativistic particles, for which $P = \rho/3$, their pressure contributes as much as their energy density does to slowing the expansion of the early universe.

Joel Primack
University of California, Santa Cruz