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same fate as the writers and entertainers who lost their livelihoods; a few others had the good fortune to be sheltered under academic freedom. I specifically restricted my comments to the physical sciences since I know that in other areas of academe where passions can run high, academic freedom may be essential for survival. Occasionally the borders overlap, as in the case of the cultural wars. For scientists who wish to engage in that battle, academic freedom allows hand-to-hand combat without fear of a mortal wound.

Giacinto Scoles asks quite reasonably whether or not the problem is real. My guess is that the problem is not enormous but that, when it does occur, it can have serious consequences. The underlying issue is whether tenure can survive. Scoles's proposed solution is quite reasonable but unfortunately the law is not: The Age Discrimination in Employment Act forbids changing a faculty member's status or introducing a review process purely on the basis of age. In any case, I hope that Scoles sustains his research at top speed for as long as he wishes, retired or not.

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Advancing Faddeev: Math Can Deepen Physics Understanding

In his letter to the editor in your September 1997 issue (page 15), Lorenzo de la Torre discussed the relationship between physics (the study of nature), mathematics (the study of structures) and reality. This is a topic that has provoked recurrent epistemological discussion in "Letters"—see, for instance the letters from Roman Jackiw (February 1996, page 11) and Paul Roman (June 1996, page 13), as well as the subsequent letters from Paul Roman, Alfred A. Brooks, and Roger G. Newton, plus de la Torre's response to them (January 1998, page 91). It is in this context that we think it useful to briefly mention the distinctive viewpoint of Russian mathematician Ludvig D. Faddeev (or Faddeyev), as well as to make a comment on a recent generalization of standard statistical mechanics.

Faddeev thoughtfully advances the idea that mathematics—through the concept of deformation, cohomology theory and related topological structures—deepens our understanding of the theoretical formalisms used in physics.[1] To be more precise, he argues that Newtonian mechanics is unstable with regard to Planck's constant h. Indeed, if a nonvanishing value is considered for h, no matter how small it would be hypothetically, the various physical observables would not necessarily commute, Poisson brackets between observables would be replaced by commutators and we would already be in the realm of quantum mechanics. Faddeev adds that, in the same sense, quantum mechanics is stable, essentially because, in the neighborhood of any finite value of h, no new (topologically) relevant mathematical features appear.

As a second illustration of his idea, Faddeev also comments on another instability of Newtonian mechanics. With regard to the inverse of light velocity $1/c$, he notes that for any nonvanishing value of $1/c$, Galileo's transformation becomes that of Lorentz, thus generalizing classical mechanics into special relativity (a stable theory in the neighborhood of any finite value of $1/c$). Faddeev's third and last example addresses the fact that special relativity is in turn unstable with respect to any nonvanishing value for the gravitational constant G (cause of curvature of spacetime), thus yielding general relativity, which is a stable theory with regard to G.

Although Faddeev addresses physical theories, his interesting point can be made even more transparent through the analysis of a physical *model*—say, the Heisenberg ferromagnet. If we add to the isotropic exchange coupling a further z-axis spin–spin coupling—call it "j"—then the $j = 0$ model is unstable with regard to nonvanishing j. Indeed, if $j > 0$, the symmetry of the system is reduced and belongs to the Ising critical phenomena universality class (stable model); analogously, if j is not too negative, the symmetry of the system becomes that of the XY ferromagnet (stable model).

Returning to the level of physical theories, it is useful to identify one more currently available example that reinforces Faddeev's point. As is well known, Boltzmann–Gibbs statistical mechanics is based on the extensive (additive) entropy, which, for systems at thermal equilibrium, yields an exponential dependence on energy. To study a variety of anomalous systems (long-range interactions, multifractal spacetime and so forth), one of us (Tsallis) has proposed the use of a nonextensive entropy, parameterized by a real number q. This entropy recovers the usual one in the $q \to 1$ limit, but generically provides a power law dependence on energy (with a cutoff for $q < 1$ and a long tail for $q > 1$). In this formulation, Boltzmann–Gibbs statistical mechanics is unstable with regard to $(q - 1)$ and provides two different stable theories—namely, superextensive and subextensive thermostatistics for $(q - 1) < 0$ and $(q - 1) > 0$, respectively.

Although it seems plausible that the present considerations are applicable in principle for any generalization of physical formalisms, naturally only those that receive experimental confirmation are useful in physics. Nevertheless, in Faddeev's words, "This is a kind of philosophy which underlines my own research."[3] Ours too.

References

1. See, for instance, L. Faddeev, *40 Years in Mathematical Physics*, World Scientific, Singapore (1995), p. 463.
2. C. Tsallis, J. Stat. Phys. **52**, 479 (1988). E. M. F. Curado, C. Tsallis, J. Phys. A **24**, 69 (1991). For a complete bibliography, contact C. Tsallis by e-mail at tsallis@cat.cbpf.br.
3. L. D. Faddeev, Asia-Pacific News, June/July 1988, p. 21.

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Arguing about History: Silicon versus the Industrial Revolution

However reliable Ian Ross's article may be on the technical development of the transistor (PHYSICS TODAY, December 1997, page 34), I have to question his grasp of history as reflected in this rather bizarre sentence: "The semiconductor odyssey produced a revolution in our society at least as profound as the introduction of steam engines and steel, as well as the total industrial revolution."

Although the semiconductor has very substantially improved our ability to accomplish certain tasks (such as performing massive calculations), its having become a component of various devices such as the telephone is nothing compared to the very existence of those devices. And however pervasive computers and their ilk have become, even in the home, they are still not as important for the reality of everyday living as the basic communication capability that the telephone has established or the improved ease of running a home that running water or just a washing machine has provided.

As for the technologies that the semiconductor has transformed, such as data-rich communications, the significance of such changes for society as a whole is really quite small relative to the transformation brought about simply by steam power (which was wildly laborsaving in manufacturing and transportation), let alone by the entire industrial revolution!

Those making overarching claims about the significance of silicon for our society ought to do some careful thinking about the actual changes that semiconductors have brought about (mostly mere improvements), recognizing that at least some of the current craze (for example, about the Internet) is mere hype, and often a substitute for substance. It might also be useful for them to consult a bit with some actual historians.

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Reflecting on Heaven: Prospects Looking Up, Data Still Needed

The delightfully whimsical letter from Jorge Mira Peréz and Jose Viña (PHYSICS TODAY, July, page 96) on whether heaven is hotter than hell calls for some modification. Specifically, they have omitted the factors of the albedos of heaven and Earth from the expression for the temperature ratio they give.

Now the albedo (reflectivity) of Earth is well known, and its value is about 0.4. On the other hand, the albedo of heaven is rather hard to estimate, even though the Bible does give some clues, such as that the streets of heaven are paved with gold and the place has lots of alabaster walls. Moreover, the inhabitants are usually clothed in white, and there must be a fair-sized number of them there by this time (of course, it can't compare in population with the other place).

Lacking hard data on the albedo of heaven, perhaps we ought to do what any good physicist does in such a situation and turn the problem around to see what we can make of it. I propose that we make some reasonable assumptions about the temperature of heaven and from that calculate its albedo. Since the albedo varies only as the fourth root of the temperature, this procedure ought to give us at least a fair estimate.

Now what can we reasonably assume about the temperature of heaven? For one thing, heaven is generally thought to be a comfortable place, else why would so many aspire to spend eternity there. The Bible concurs in—and in fact encourages—this belief. Of course, although we don't know what form our heavenly bodies may eventually take, the biblical heaven, by all accounts, is highly anthropomorphic, so it may not be too far off the mark to assume that heavenly temperatures are close to earthly temperatures. In this case, the albedo ratio becomes the fourth root of 8, or 1.68. Taking Earth's albedo as 0.4 gives us a heavenly value of about 0.66, which also happens to be the value for the planet Uranus—a coincidence that should not be taken to suggest that Uranus would be a heavenly place to spend eternity (it's mighty cold there).

Our estimated albedo for heaven is at least not unreasonable. With such a relatively high reflectivity, heaven would indeed be a bright place, and this is in agreement with biblical information. Our albedo value for heaven is also not far from the values for gold and for angelic raiments, though I don't have any data for alabaster.

Perhaps some of your astute readers can fill in the gaps. What a pity we don't have access to relevant experimental data, which seem to be as well hidden as the Higgs boson.

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Identifying the Inventor: Tesla's True Ethnic Origin

In discussing the history of physics research at Westinghouse Electric Corp (PHYSICS TODAY, August, page 53), Irwin Goodwin misleadingly refers to inventor Nikola Tesla as having been Croatian.

Technically, Tesla was indeed born in Croatia, which was then (1856) an Austro–Hungarian province. However, in these current times of political correctness, it is necessary to note that he was not an ethnic Croatian but rather an ethnic Serbian. As Margaret Cheney explained in her biography, "The tiny house in which he was born stood next to the Serbian Orthodox Church, presided over by his father, the Reverend Milutin Tesla. . . ."[1] And as she then emphasized, "Ethnic traditions are often most tenaciously observed by transplanted minorities and the Teslas were no exception."

Tesla settled in the US in 1884, became a naturalized US citizen in 1889 and lived out the remaining 50-plus years of his life in his adopted country. Today, his origins are still remembered in Serbia, where his visage graces the five-dinar banknote.

Reference

1. See, for example, M. Cheney, *Tesla, Man Out of Time*, Prentice-Hall, Englewood Cliffs, N. J. (1981), p. 6.

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Finding Clues: Laser Technology Hints at Indian Bomb Materials

In his report on the nuclear tests conducted by India and Pakistan in May (PHYSICS TODAY, July, page 45), Irwin Goodwin states that "at their press conference, the [Indian] scientists refused to describe the types of fission materials. . . ." In this regard, it should be noted that India's Bhabha Atomic Research Centre does have sophisticated narrow-linewidth tunable laser system technology that could be applied to enrich uranium. This is an oscillator–amplifier dye laser system excited by high pulse-repetition-frequency (prf) copper vapor lasers.[1] Its oscillator is of a hybrid multiple-prism grazing-incidence grating design[2] and is capable of yielding the tunable narrow-linewidth laser emission necessary for selective excitation. It is well known in the laser community that this class of high-prf tunable narrow-linewidth laser technology can be applied to atomic vapor laser isotope separation.[3]

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3. I. L. Bass, R. E. Bonanno, R. P. Hackel, P. R. Hammond, Appl. Opt. **31**, 6993 (1992).

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Correction

July, page 20—In the story on microcalorimeters, the affiliation of Norm Madden, Jeff Beeman and Eugene Haller should have been given as Lawrence Berkeley National Laboratory, not as Lawrence Livermore National Laboratory. ■