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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 im-