Guest Comment: A generation lost?

"Foreman says, these jobs are going boys, and they ain't coming back."
My Hometown, Bruce Springsteen (1984)

Reggie is thirty six, a physicist six years past his Ph.D. Reggie is tall and dresses with the relaxed precision I expect to see in an urban architect. He speaks of physics, painting, literature, and film with a fluidity that reveals the perceptive intellect behind his confident and stated exterior. His clothing is labeled "No Fears."

I am reading a paper by Reggie and his co-worker entitled, "Modeling time series data and synchronizing chaotic systems."[1] The paper presents an idea which will delight scientists working in nonlinear dynamics. It shows how to synchronize a theoretical model to an experimental chaotic time series by using the time series as the driving input to the model. The idea is a fresh approach to a fundamental issue in science: determining when a "model" and "experiment" are close.

The correctness of the idea gets you instantly. It should begin a mini-research industry of spin-off applications. It's just the sort of idea—easy to remember, good potential for practical applications—which is ideal for a young researcher, especially when he is asking for funding. Like many "simple" ideas it is the product of hard work over many years. The formula for discovery in an interdisciplinary field like nonlinear dynamics is easily stated: become an expert in several fields (in this instance, differential equations, computing, statistical modeling, and time series analysis) and then creatively link the core elements and recent discoveries in these fields with the insight born from a passion for understanding. This is what Reggie did. As of tomorrow, Reggie will be an unemployed physicist.

Reggie tells me he has enough savings to "hold out for six months," at which time he hopes to hear about some grants he is preparing. In the interim, he thinks it might be possible to work as a teacher at the University where he has been a researcher and teacher for the past six years. I ask about health care: "No, I won't continue my health care plan through COBRA payments, but I have been healthy the past six years." He continues, "Look, it's survival of the fittest. This is my best idea so far. If I can't find support for this type of work then...," at which point Reggie pauses and does not finish the thought. For Reggie, physics is a vocation. It was never a career move.

Reggie is single. Like most physicists of his generation, Reggie's only realistic prospect to find stable work in physics will occur after two, maybe three, temporary appointments, several years past his Ph.D. Reggie knows the score: even if he lands a permanent position he won't keep it unless he gets external funding, irrespective of the quality of his science, teaching, and service. Given this fact, Reggie sees little difference between a permanent position and a soft money position. To Reggie, prospects for funding appear to depend on whether his work can be fitted into one of the existing programs within a funding agency, and little on the quality of the science. In any case, it is hard to imagine how a young researcher can succeed in scientific academia today without focusing exclusively on short term projects, goals, and results: hit and run physics.

Bob is fifty two, twenty six years past his Ph.D., a full professor noted for his substantial contributions to seemingly disparate fields in physics (nuclear physics, group theoretical methods, Lie theoretic methods, singularity theory, nonlinear dynamics). Bob does not practice hit and run physics. In fact, there is an obvious unity to all Bob's work. Bob attacks the big questions—"What is the world made of?", and more recently, "How is the world organized?"—in the most ordinary way possible, one result at a time. Like a good banker, Bob understands the laws of compound interest. Continual investment does not amount to much after a few years, but over a professional lifetime it will pay millions. Put $10,000 in a municipal fund today and in five years it produces $17,623, in thirty-five years it produces $527,996.

Reggie and Bob are visiting myself, James, and several other young physicists in order to discuss some technical issues in nonlinear time series analysis. The discussion often turns, though, to the bigger questions: "What should a 'normal form' theory of nonlinear systems look like?," "Why is it that funding for nonlinear dynamics research falls through the cracks at NSF?," and "How are we going to apply our techniques to get real insight into experimental data sets ranging from the complex wonderings of the jet stream to the chaotic chattering of a bouncing ball."[2,3] The one thing we are all passionate about is "data analysis." To us, an insightful analysis of an experimental data set from a laser, chemical oscillator, or surface wave, can have the beauty of a Bach Fugue.[4] Since we are ultimately attacking the big questions—one result at a time—and since we are all experienced in pulling simplicity out of real world chaotic and complex data sets, we are all confident that in time we will build a scientific framework of real value to workers across all the sciences. We think our colleagues in other fields of physics must be jealous of us. They just can't be having as much fun as we are as we muck around trying to make sense of data from mud fields or bioconvection of bacteria.[5,6]

James is also six years past his Ph.D. Despite protests to the contrary, he is already well known in his field.[7] At a recent professional meeting the most common phrase on everyone's lips seemed to be, "So what does James think about ... ?" James has a family with two children. Evidently, unlike many of our generation, James decided not to put his life on hold while becoming a physicist. James' current postdoctoral position at Los Alamos ends within the next two months. As I write this, James is scrambling around seeking job interviews "behind the fence." James says such jobs are in "applied work peripherally related to my research," research he would like to continue.

During an informal get together Salman goes to the board to explain some of his recent work on how to calculate Lyapunov exponents.[8] His impromptu lecture turns into a virtuoso display of pushing around Lie algebras and series. These are the good bits to being a physicist. The net result, he explains, is that "if we do all this analytic work one time up front, then the numerics turn out to be rather easy." We are all impressed. Each of us has tried our hand at this problem at some point, and now Salman has finally shown us the "right" way to do it. His result is eloquent. Better yet, it leads to a remarkably efficient numerical scheme. Salman is also six years past his Ph.D., and in six months time will probably be in the same boat as Reggie and James. He says he has done the normal "mailings" and is hoping for the best, but there is a definite tone of resignation in his voice.

Yesterday—during an evening conversation between Reg-

gie, Bob, and myself—Reggie surprises me with his reply when I ask him how much longer his position continues at his University. Reggie looks down at his watch, and then he looks at me and says, with a little hint of bravado, "two more days." Then Reggie strongly defends the privilege of being a physicist despite his uncertain future. I work at being convinced. I do know that both Bob and I are genuinely taken by Reggie, James, and Salman. We are impressed by their abilities and creativity. We know firsthand the discipline and devotion required to achieve mastery of the art which they practice with such ease. We share an unspoken knowledge that common passionate concerns are a wonderful foundation on which to build friendship. This is another of the privileges in being a physicist. Getting to know and work with people like this. Then Bob startles me by saying, "I am sad because of a generation lost."

I cannot speak for Reggie when I write this, but I hope I speak for physicists of my generation when I say: We are confident that we are asking the right questions. We are confident in our skills and training to pursue these new challenges. We are confident that nature will reward our efforts. We will pursue the big questions of physics of our generation the only way we know how, by collectively chipping away at the hard block of marble before us, chisel in hand, one strike at a time. We know that the beautiful figure we imagine to be there will pale in comparison to what the block will ultimately reveal. We are confident that our work will lead to practical results contributing in a substantial way to the greater good of our fellow citizens, just as the work of previous generations of physicists has, physicists whom we admire and respect, physicists who inspired us to take up the challenge and continue on toward the never ending frontier. We know that our fellow citizens are keen to learn more about what we do especially in some specific areas such as astrophysics and chaos, and we promise to share our inspiration, insight, and occasionally frustration, with them.

But we are realists. As physicists, we like to be grounded in the facts. And our version of the facts is this: *Many creative, talented, intelligent, competent, and devoted physicists in our generation will not be able to find their sole material subsistence teaching and doing physics.* Those contemplating a career in physics should consider this version of the facts carefully. Decisions easily made in younger days have a way of getting heavier as you get older—"Life is what happens to you when you are busy making other plans." [9] For those who can stay, and for those working elsewhere, we just ask that all of us not forget, we are all physicists. We love physics. We do physics. Funding or no funding. Salary or no salary. Union card or no union card. If we don't pass on our knowledge, skills, and experience to the next generation, who will?

And to the older generation, I have one more thing to say. Work with us in revitalizing the physics curriculum for those interested from six to sixty. We need to share the secrets of the universe with more people in a way *they* find interesting and exciting. Work with us in making physics the elective of choice in the college catalog. Work with us in explaining to our fellow citizens why we are excited about our work and what it takes to get it done. Work with us in supporting a diversity of peoples, topics, and research endeavors within existing physics organizations. Work with us in reforming University Departments corrupted by the money chase. Work with us or watch even more jobs vanish.

And what about all those complex and nonlinear problems?

No worries. We'll solve them too.

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[2]R. Gilmore, "Analysis of complex signals with spatial and temporal structure," talk presented at Nonlinear Time Series Workshop, Santa Fe Institute, 2/23/94.
[3]N. B. Tufillaro, T. Abbott, and J. Reilly, *An Experimental Approach to Nonlinear Dynamics and Chaos* (Addison-Wesley, New York, 1992).
[4]A. S. Weigend and N. A. Gershenfeld, *Time Series Prediction: Forecasting the Future and Understanding the Past* (Addison-Wesley, New York, 1994).
[5]B. Hallet, "Spatial self-organization in geomorphology: From periodic bedforms and patterned ground to scale-invariant topography," Earth Sci. Rev. **29**, 57–75 (1990).
[6]T. J. Pedly and J. O. Kessler, "Hydrodynamic phenomena in suspensions of swimming microorganism," Annu. Rev. Fluid Mech. **24**, 313–358 (1992).
[7]J. Theiler, S. Eubank, A. Longtin, B. Galdrikian, and J. D. Farmer, "Testing for nonlinearity in time series: The method of surrogate data," Physica D **58**, 77–94 (1992).
[8]S. Habib, "Symplectic analysis of chaotic dynamical systems," talk presented at Los Alamos National Labs, 2/28/93.
[9]J. Lennon.

KELVIN ON HERTZ AND FARADAY

During the fifty-six years which have passed since Faraday first offended physical mathematicians with his curved lines of force, many workers and many thinkers have helped to build up the nineteenth-century school of *plenum*, one ether for light, heat, electricity, magnetism; and the German and English volumes containing Hertz's electrical papers, given to the world in the last decade of the century, will be a permanent monument of the splendid consummation now realised.

William Thomson (Lord Kelvin), in the preface to Heinrich Hertz, *Electric Waves* (Macmillan, 1893; reprinted by Dover, New York, 1962), p. xv.