Communicating the Romance of Mathematics

Philip J. Davis begins his March 2006 *Notices* Opinion essay "The Media and Mathematics Look at Each Other" by quoting two journalists. The first, Gina Kolata, a science writer for the *New York Times*, wrote that

> [n]ewspapers are not there to educate…people about the mathematics that underlies search engines unless there is something…that makes it new and compelling… With most things we use—a car, an iPod, a DVD, most of us don't really care how it works.

The second, former *New York Times* editor Rob Finer, quoted by Sara Robinson, said that

> [m]athematics has no emotional impact. What physicists do challenges peoples' notion of origins and creations. Mathematics doesn't change any fundamental beliefs or what it means to be human.

The bulk of Davis's piece is spent challenging the first quotation, demanding, in effect, that the *Times* inaugurate a column explaining how the iPod works.

This surprised me somewhat, since, to me, Kolata's comment seems perfectly reasonable, albeit perhaps somewhat unambitious. By contrast, Finer's is an unusually eloquent articulation of exactly the misconception that leads to most of society's confusions about what mathematicians do. As such, it could serve as a rallying cry and focal point for our attempts at outreach.

Why do I say this? Mathematicians are often bewildered that although our subject is no more arcane than theoretical physics, the public seems to have a steady appetite for nontechnical accounts of contemporary physics but not mathematics (c.f. the celebrity of Richard Feynman, Stephen Hawking, and Brian Greene, as compared with, um, basically no mathematician).

Mathematicians often explain this by claiming that physics, unlike mathematics, is about the fundamental mysteries of the universe, so we cannot expect the general public to be as curious about what we do. That is, they paraphrase Finer. To me, this response is not only wrong but also dangerous, evidence of a cancerous inferiority complex that burdens our subject.

I take a different approach. In order to make nonspecialists connect with a highly technical discipline, it's necessary to use metaphors to awaken the imagination. In other words, we must create a point of contact with an existing romantic impulse. Here we begin to see why the physicists are so successful! The romance of physics is blindingly obvious: to find it, just get out of the city, wait until nightfall, and look up. The dizzying skyscape you see is precisely the electric spark that connects physics to romance.

The romance of mathematics, however, is somewhat more elusive. It's related to the romance of pattern, the romance of mystery and mysticism, the romance of a solitary warrior doing lonely battle with destiny. Put another way, physicists seek to understand what God has wrought; mathematicians seek to understand what it feels like to be God.

Our challenge, then, is to express the romance of mathematics. We are notoriously bad at this; even when talking with other professionals, we tend to take an "I-know-it-when-I-see it" attitude, and are much happier to debate questions about when and where this romance is present than what it actually is.

So, what can be done? The problem of communicating mathematical romance to non-mathematicians is to be sure a daunting one, but it strikes me as absolutely essential. Indeed, the only alternative is to accept that mathematics, unlike physics, comes from a completely inhuman place and has no place in social discourse. I, for one, have absolutely no interest in participating in such a discipline.

Our goal of explicating the romance of mathematics does have one advantage over other related attempts at mathematical evangelism. A mathematician who works in, say, automorphic forms brings to the table a vast repertoire of technical knowledge; in order to convey her research in a nontechnical way, she must construct a whole series of simplifying tricks and metaphors. On the other hand, in order to write about mathematical romance, we need to first find a way to articulate it to one another. That is, the problem is not how to translate something for a mass audience, but rather how to say it in the first place. As such, it seems closer in spirit to actual mathematical research than do most attempts at popular mathematical writing.

Besides a basic frontal assault on the problem, the technique that seems most promising to me is to find connections between mathematics and art. Art historians and critics have developed an extremely sophisticated language for discussing aesthetic aspects of abstract and conceptual works, and they have seamlessly integrated these discussions into an analysis of social and cultural movements. This provides us with a ready vocabulary and extremely fertile source of analogies that can serve both as crutches for our less technically savvy audiences and as inspiration for our own work.[1]

All of which brings us back to the iPod. Davis would like journalists to use the iPod as an excuse to explain the mathematics behind digital music files. I have to admit that I don't particularly care how my iPod works. I do, however, think it's an extremely beautiful object: sleek, attractively proportioned, mostly smooth but with a few surprisingly sharp edges. Doesn't that sound a lot like your favorite theorem? Forget about how it works: I want someone to write about how mathematics and the iPod are beautiful for exactly the same reasons.

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[1] *See my article "Grothendieck, Braque, and the formality of relativism" (to appear) for one such example.*

Letters to the Editor

New Orleans Update

I was recently on an airplane returning to New Orleans from a visit to New York. The two people in the row behind me were speaking so loudly that I could not help but overhear. Each was a teacher who was volunteering over spring break, to help out some of the people in the Lower 9th Ward of New Orleans whose houses were destroyed by the floodwaters that inundated their neighborhood in the aftermath of Hurricane Katrina. After some discussion of this aspect of their trip, the discussions turned to which restaurants and music clubs they intended to visit during the next week. Each of them had made reservations in some of the better restaurants in the city and they were both well informed on which clubs were best for the particular music that they enjoyed.

For me this incident captures the story of New Orleans today, what one astute local columnist calls "The New Normal". The areas of the city that did not flood, including the area where the Joint Meetings will be held, are once again filled with people, restaurants and clubs. If anything they are more crowded than before the storm, as people whose houses were damaged or destroyed have moved to these neighborhoods. Mathematicians with favorite restaurants in the French Quarter or Garden District would be wise to reserve a table before coming to the meetings. Those neighborhoods that suffered the worst of the flooding, both rich and poor, are facing uncertain futures and have only made small progress toward rebuilding.

As mathematicians think about the upcoming annual meeting in New Orleans, I think that it might be useful for them to get the perspective of a resident mathematician on what to expect during their stay here and how different it may be from their previous visits to the city. In short, the story is complicated and cannot be encapsulated in a one-line headline or in a thirty-second soundbite. This has made it very difficult for people outside the region to understand the situation here; national media either do not see the complexity of the story or are not willing to devote the resources to report it comprehensively. A good source for detailed information is `http://www.nola.com`.

The situation at the colleges and universities is also complicated. I am more confident of my knowledge about the situation at Tulane, the one local institution with a Ph.D. program in mathematics. While Tulane University suffered severe losses due to the storm and had to eliminate some programs, dismissing tenured faculty, the mathematics department was unaffected by these cutbacks. During the fall 2005 semester, when the university was closed, we placed most of our graduate students at other institutions. A number of these students decided to stay at these institutions, decreasing the size of our graduate student population. We are currently in the process of rebuilding the graduate program. The Tulane administration is implementing a plan to stabilize the finances of the university. During the next few years we will see if this plan is successful.

—Morris Kalka
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Don't Come Between Mathematicians and Funding

I was surprised to read the plea to reject military and DHS [U.S. Department of Homeland Security] funding for mathematical sciences in the June/July *Notices*. Those institutions have a legitimate need for mathematical work, such as network dynamics (used to combat terrorist cells and protect our own infrastructure from natural disasters). If particular mathematicians disapprove of military policy, they are free to turn down any offers of funding. But to ask the AMS to come between other mathematicians and legitimate funding from the military and DHS is selfish.

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Serge Lang and the HIV Consensus

In the remembrances of Serge Lang (*Notices*, 53, No. 5, p. 536), many individuals recalled Lang's "trouble-making" in connection with HIV and AIDS. We support Lang's conviction that basic questions regarding HIV and AIDS have not been adequately addressed, and at the least, an open and honest discussion of the flaws of the HIV hypothesis is long overdue. Lang's "files" on HIV and AIDS are now publicly available in PDF form, at the URL `http://www.reviewingaids.org/awiki/index.php/Document:Lang`. Here, readers can view nearly 600 pages of documentation, spanning a period of more than twelve years. This and other information available at the AIDS Wiki (`http://www.reviewingaids.org/awiki`) should allow the mathematical community an opportunity to see specifically why Lang remained so skeptical of the current HIV consensus.

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On *Numb3rs*

As the principal math consultant for CBS's *Numb3rs*, I was disappointed by the unremitting negativity of Sarah Greenwald's Opinion column [*Notices*, August 2006] and the AMS news release about it [see `http://www.ams.org/ams/press/home.html`], given the show's remarkable success, recognized on `http://www.ams.org/ams/mm51-crime.pdf`, and by the recent Carl Sagan Award given to the

show's creators, Cheryl Heuton and Nicolas Falacci, by the Council of Scientific Society Presidents.

In quoting me from a March 2005 interview, Greenwald ignores the progress of Amita Ramanujan: She has indeed become more of a collaborator and received a prestigious thesis award and a tenure-track offer from the Harvard math department!

Calling Charlie a stereotypical mathematician misses the richness of his character and the way episodes frequently capture mathematicians' spirit: the joy we get from explaining our ideas, the frustration and occasional delight from working on hard problems, how we grope our way to the formulation of a problem—let alone its solution, and how we can be wrong even when we're sure we're right.

Before it ever aired, the show reached out to mathematicians at the January 2005 AMS meeting. Many have responded with ideas and encouragement, and every ten days other mathematicians join me in reading a script and offering suggestions. Along with the show's researchers, we scour the Internet and pure and applied math journals, gleaning terminology, equations, and graphics.

Sure, *Numb3rs* in its brief "Charlie visions" and "audience visions" can offer only a taste of math and science, and sometimes that taste is artificially sweetened, but in this age of the Internet and Google, just having a show that regularly makes serious, plot-driving use of things like the Riemann Hypothesis, P vs. NP, the Heisenberg Uncertainty Principle, and Markov Chains inspires people to find out more on wonderful websites like Wikipedia and Eric Weisstein's `mathworld.wolfram.com` and Mark Bridger's `atsweb.neu.edu/math/cp/blog`. (With Eric's colleagues at Wolfram Research, Ed Pegg, Michael Trott, and Amy Young, they are among the regular "math advisors".)

I wish Greenwald and the other consultants at `hollywoodmath.com` success in providing better math and science to Hollywood. But we "*Numb3rs* regulars" realize that if the show took all our advice it would not be rolling into its third season leading the Nielsens on Friday nights and saying "bring it on" to NBC and ABC, a television show where the cool, sexy FBI agents like and admire a passionate, idealistic young math professor—not just for his "beautiful mind", but for what they (and the kids watching?) learn from him every week: that a mathematician's way of looking at the world offers insights and beauty…and gets results!

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Hardy, Ramanujan, and Interesting Numbers

Ken Ono's mention of the story about Hardy, Ramanujan, and 1729 has prompted me to point out one detail usually overlooked. Here is a bit of the original account (in Hardy's obituary of Ramanujan):

> I had ridden in taxi-cab No. 1729, and remarked that the number $(7 \cdot 1 \cdot 19)$ seemed to me a rather dull one…"

This shows that Hardy himself had already, automatically, checked whether there was anything interesting about the factorization of the number.

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Ramanujan and Religion

Ken Ono's article (*Notices*, June/July 2006) offers new information to readers about Ramanujan's hometown. There are several historical quotes by eminent mathematicians such as G. H. Hardy and C. P. Snow. The author interestingly forms conclusions on some of these quotes, construing them to the present day number theory. Finally, I have enjoyed the article about Ramanujan's contribution to modern number theory and how his work connected to some famous theories developed after his death. Thanks to Ono for providing a list of conjectures, theorems and functions named after Ramanujan solely or jointly. We can hope that this list increases in the years to come, as research in the direction of mock theta and other functions is advancing. The question still unsettled to me as well as many other mathematicians is, "are there some similar examples of extraordinary science in any branch without formal education and schooling?". Ono's interpretation of the involvement of religion in Ramanujan's life is probably correct. This recalls to my mind a quotation by a famous Hindu monk and contemporary of Ramanujan, Swami Vivekananda. Explaining the science of Raja-Yoga he said "...If there has been one experience in this world in any particular branch of knowledge, it absolutely follows that that experience has been possible millions of times before, and will be repeated eternally..". Assuming that this assertion is true, we might have had some people of Ramanujan's calibre prior to him and we can expect positively to have such personalities in the future. Interestingly, the author pointed out that Ramanujan had a dramatic turn in his life after he came across Carr's book (see p. 641 in the article). We can expect such dramatic incidences in the future. Another interesting religious incident in Ramanujan's life was that Komalatammal, his mother, had a dream in which their family goddess authorized Ramanujan to visit England. Ono mentions this event very briefly. There are some historical examples in India of parents having a vision of their favourite god hinting that an unborn child would become a great personality. It is available in the literature that parents had vision of a god in their dreams before giving birth to Sri Ramakrishna (1836–1886), the revered hindu saint, whose popularity to western countries was conveyed by Roland Romain through his book. Also, there are authentic writings available that the grandfather of Sri Annamacharya (1408–1503) (composer of 32,000 spiritual songs in his lifetime and a great saint), had a vision of his village goddess who gave hint about his grandchild.

Attributes such as inspiration and motivation matter in conducting mathematics research and for that

matter this is true for excellence in any branch of science. The article by Ken Ono, "Honoring a gift from Kumbakonam" is a fine example of a combination of both of these attributes.

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Writing *Numb3rs* Activities

The opinion piece, "Complex *Numb3rs*" (*Notices*, August 2006) presented only the "teaser" part of my presentations, emails, and conversations about *Numb3rs*. Now is the time for the rest of the story.

CBS, Texas Instruments, Inc., and the National Council of Teachers of Mathematics weekly give the American public an opportunity to use mathematics beyond the classroom. They also allowed the mathematics community an opportunity to work together to produce student activities to accompany the show.

The writers and reviewers with synopses of the mathematical scripts are weekly in a true problem-solving situation. I was accurately quoted about my initial reaction to the synopses. The reaction is not atypical of anyone in a problem-solving situation involving unknown mathematics. That is only part of the story.

Activity writers practice Pólya's problem solving heuristics [*How to Solve It*, 1965, reprinted by Dover Publications]. We work as a group to understand the mathematics and translate it into activities. We create the activities, vet them with the mathematics community and nonmath people, revise, and extend them to complete Pólya's problem-solving steps. The activities use the show's context but can stand alone.

Activity creators worked under intense pressure. That does not lessen the value of the activities. Producing timely activities gives an example of mathematical power. Activity writers are practicing what they preach by producing results as we expect students to produce on examinations. Do we make errors? Possibly, just as students do. That no more makes the activities inappropriate than do student errors make tests inappropriate.

And there is yet another page to the story. The mathematics activities are not in normal textbooks, not in the traditional curriculum, and not tested. *Numb3rs* with the accompanying activities allow all to see mathematics outside the classroom and used to respond to crises today as in the past. Operations research grew from a need to move troops and supplies to battlefields. The use of mathematics then neither endorsed nor promoted war. Similarly, that *Numb3rs* uses mathematics to combat criminal activity does not endorse crime.

I feel privileged to be on the *Numb3rs* activity-writing team. And that, from my perspective, is the rest of the story. Professor Greenwald, please use all of the story and not just selected parts of it.

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Correction

Queries and Correction to "A system of axioms for set theory for the rationalists" by Jan Mycielski, *Notices* **2** (2006), 206–213.

Correction. It is known that ZFC plus the existence of one strongly compact cardinal implies $\mathrm{AD}^{L(\mathbb{R})}$. Thus $\mathrm{AD}^{L(\mathbb{R})}$ can be omitted from the list of axioms of ST.

This was proved around 1990 by Steel and Woodin, as an application of the then new core model results of Steel and previous results of Woodin. There have been refinements of the original proof both in terms of weakening the strong compact assumption and obtaining stronger determinacy results. The essential details can be found in Section 7B in [3] and in [1].

Queries. But there are simple generalizations of $\mathrm{AD}^{L(\mathbb{R})}$, for which we do not not know if they are provable or consistent in ST. Let $\mathbb{R}$ denote the Baire space ω^ω with a bounded complete metrization ρ, $2^{\mathbb{R}}$ the space of non-empty closed subsets of $\mathbb{R}$ with the Hausdorff metric

$$d(X,Y) = \max[\max_{x\in X} \rho(x,Y), \max_{y\in Y} \rho(y,X)],$$

B and **F** the classes of Borel and closed subsets of $\mathbb{R}$, respectively.

For any classes of sets **P** and **Q** we denote by $\mathbf{P} \Rightarrow \mathbf{Q}$ the following proposition:

For every closed subsets $\mathbf{S}_I$ *and* $\mathbf{S}_{II}$ *of the space* $2^{\mathbb{R}}$*, if for every* $X \in \mathbf{P}$ *either* X *includes a set of* $\mathbf{S}_I$ *or* $\mathbb{R} - X$ *includes a set of* $\mathbf{S}_{II}$*, then the same is true for every* $X \in \mathbf{Q}$*.*

By a theorem of Martin [2], $\mathbf{B} \Rightarrow L(\mathbb{R})$ immediately implies $\mathrm{AD}^{L(\mathbb{R})}$. Thus the question arises if $\mathbf{B} \Rightarrow L(\mathbb{R})$ follows from $\mathrm{AD}^{L(\mathbb{R})}$. We know that $\mathbf{F} \Rightarrow \mathbf{B}$ fails.[1] Is $\mathbf{F}_\sigma \cap \mathbf{G}_\delta \Rightarrow \mathbf{B}$ a theorem of ZFC?

References

[1] P. B. Larson, *The stationary tower; notes on a course of W. Hugh Woodin*, Vol. 32 of University Lecture Series; AMS, Providence, RI, 2004.

[2] D. A. Martin, Borel determinacy, *Ann. Math.* **102** (1975), 363–371, and A purely inductive proof of Borel determinacy, *Recursion theory*, Proceedings of Symposia on Pure Mathematics, AMS, Vol. 42 (1985), 303–308.

[3] J. Steel, *Core model iterability problem* (Section 7B), Lecture Notes in Logic, ASL, Springer–Verlag, 1996.

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[1] *Choose* $\mathbf{S}_I = \mathbf{S}_{II} =$ *the class of closed sets of measure* $\geq \frac{1}{2}$ *relative to a continuous probability measure in* $\mathbb{R}$*, and* $X \in \mathbf{F}_\sigma \cap \mathbf{G}_\delta$ *such that neither* X *nor* $\mathbb{R} - X$ *includes a closed set of measure* $\frac{1}{2}$*.*