Commentary

Soft matters matter

Two opinion pieces from the pages of PHYSICS TODAY have traveled with me for the past seven years, across three universities, and are always kept in clear sight of my desk. In "An open letter to the next generation" (July 2004, page 56), James Patterson's self-reflection is a simultaneously beautiful and brutal assessment of his academic career, with personal insights for why he was not more successful. Anita Mehta's "Physics: No longer a vocation?" (June 2008, page 50) eloquently presents a scathing criticism of petty politics in academics and its corrosive influence on physics as an "ideas- and imagination-based enterprise." Although my yellow highlighting faded years ago, I see these articles as shining examples for openness and transparency, especially in dealing with personal topics in a public forum. With their works in mind, I offer a postdoc's opinion on a subject that's become important to me as I chart my path toward an academic career.

Several years ago as a graduate student, I was socializing with a group of other grads that were meeting for the first time. We were making introductions, and when my turn came, I said that my research in soft-matter physics was on the mechanics and morphogenesis of plant roots. Without missing a beat, a student in high-energy theory replied, "Wait. Is that even physics? Where's your $\hbar$?"

We all laughed and continued from there, but those two questions squarely hit on a personal insecurity I was wrestling with at the time. My self-identity as a physicist-in-training was intimately tied to the traditional coursework of quantum physics, electricity and magnetism, statistical mechanics, and so forth. However, I lost that sense of orientation when my graduate research didn't neatly fit into the standard physics subfield categories. I fell into the turmoil that typically comes with an identity crisis, but I eventually found resolution when I began to see myself as a scientist practicing physics rather than as a physicist practicing science. That shift in self-perception brought an intellectual and personal liberation, but those two questions—Is that even physics? Where's your $\hbar$?—have been on my mind again lately.

Over the past few years, several of my colleagues in soft matter have applied for or secured physics faculty positions. As I listen to their experiences, a handful of recurring job interview questions seem to echo that grad school banter: Why does soft matter belong in a physics department? And is it really physics? Since I'm still a first-year postdoc, I haven't sat on any faculty search committees, nor am I privy to departmental hiring policies and politics. However, I have to wonder about the underlying motivations behind those subtle barbs. Are they truly innocuous interview questions meant to reveal a candidate's character, or is there an undercurrent of coldness toward interdisciplinarity from more established subfields of physics? Being an experimentalist, I find it best to turn to the data first.

The Physics and Astronomy Classification Scheme (PACS) from the American Institute of Physics was originally introduced to aid in indexing and retrieving scientific content in the era before modern Web searches. Authors self-categorized their work with PACS codes that identified both the subfield and specific research topics. To understand connections across physics subfields, four researchers analyzed papers in the Physical Review series of journals from 1985 to 2009 that had two or more PACS codes.[1] In the network-based analysis, each PACS number was a node, and each pair of PACS numbers appearing on a paper formed a connection. As the authors stated, the number of connections to a node is "indicative of the importance of a PACS code compared to the 'rest' of physics. . . . In our data, the core of the network has been dominated by those PACS codes that belong to the main branches of Condensed Matter and General Physics." The authors then emphasized "that there is an important trend of the PACS codes belonging to Interdisciplinary Physics to steadily migrate towards the core, so that at present these already occupy a significant fraction of the core." Even though scientific output is a proxy measure for trends in physics, those data are clear evidence of a rising tide toward interdisciplinarity.

But how do such data help us interpret the attitudes behind tone-deaf questions? Perhaps those research trends and the ossification Mehta wrote about drive an all-too-human resistance to change. Or maybe the increasingly fierce competition for high-quality students, grants, and glossy journal publications induces an unconscious us-versus-them tribal mentality.

Regardless, the data offer insights on why a few individuals might express coldness to an interdisciplinary research program. Such attitudes are not new, but now they have been well-documented by science policy researchers. Studies from the 1980s and 1990s show that on one hand, many scientists agree that interdisciplinary research is essential for progress, but on the other, they view the quality of interdisciplinary results as second-rate and lacking in depth.[2] I take that as clear historical evidence of a mind-set that would express skepticism, even hostility, to any of the emerging interdisciplinary fields that are gradually moving to the core of physics research. More optimistically, however, studies of doctoral graduates from 2004 to 2007 have shown that performing interdisciplinary research as a graduate student increases the chances of obtaining a faculty position.[3] Thus the trends in physics research quantified by PACS data are paralleled by a progressive shift in attitudes that suggest casual elitism may simply be coming from a fading minority.

My motivation for writing this Commentary does not come from a special love for interdisciplinarity, nor from an urge to pick a fight where there is no fight to pick. Rather, I am motivated by the two articles posted at my desk. By opening themselves up and sharing personal views, Patterson and Mehta enabled younger physicists to learn from their experiences. The tides are constantly changing what it means to study contemporary physics. Eventually, the current shift toward interdisciplinarity will itself fade, and the next trend will

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take its place. If we do not take time to openly reflect on our individual and collective experiences as Patterson and Mehta have, then we risk becoming elitists who repeat the mistakes of those who still look down on interdisciplinary physics.

The introduction to the American Institute of Physics 2013 annual report focused primarily on administrative matters, but one passage seems particularly relevant here: "By embracing change, we are open to learning more and are able to adapt more quickly to changing needs. By driving change, we can strategically apply our resources to address specific problems or chart new directions." My hope is that someday, when my generation is older, grayer, and discussing science with our juniors, we will remember those words and embrace the inevitable changes that come with time.

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Letters

Ultrafast camera's early history

For the record, scientists at Los Alamos National Laboratory developed systems that use a streak tube and image compression to record ultrafast two-dimensional movies of transient events some 30 years ago[1,2] (PHYSICS TODAY, February 2015, page 12). A cylindrical lens focuses the light from a 2D scene into a 1D line, which is actually a tomographic projection integral containing unfiltered information from the entire image. Four such time-dependent projections of a rapidly evolving scene, one every 45 degrees, were fed into coherent fiber-optic ribbons and sent some 25 m to the photocathode of a streak tube. The fiber-optic ribbons, filtered by both wavelength and mode, achieved subnanosecond time resolution. A digital video system recorded the resulting spacetime streak-tube image, with each scan line containing a time sample of the four projections.

In the data analysis, a modified version of G. Minerbo's maximum entropy tomography algorithm[3,4] was used to construct a frame of the output movie from each scan line of the streak-tube image. A later variant of the algorithm produced a 3D spacetime tomographic reconstruction using a time-integrated 2D image of the same scene, exposed for the duration of the streak-tube sweep, as a tomographic projection along the time axis. The reconstructed movie solution is then constrained to add up to the time exposure.

More recently, workers at the Dual Axis Radiographic Hydrodynamic Test Facility at Los Alamos successfully used several streak-tomography systems as near-real-time beam diagnostics in the commissioning of the facility's high-current pulsed electron accelerator.[5]

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A final note on bell-like tones

Because I am a little unclear on some of the physics involved, I have been hesitant to speak on the issue of bell-like sounds from a piano. However, the letter from Myron Levitsky (PHYSICS TODAY, March 2015, page 9) has motivated me to comment.

Although the Saint-Saëns piano concerto Levitsky discusses is beautiful, I believe that its octaves and thirds are more characteristic harmonics of organ pipes or bowed strings than of bells. The distinctive sound of bells comes from their complex, nonlinear harmonic series that typically contains dissonant tones relatively low in the series.

By far the best piano bell simulation I've heard comes in a hauntingly beautiful section of "Copacabana," the fourth dance in Darius Milhaud's Saudades do Brasil, which I believe is intended to evoke the sweet sound of distant bells. Hear a brief audio file of the section at http://rtcutler.com/Audio/MilhaudBells.mp3, and see a sample of the score below. The work is basically in C major, but I call your attention to the dissonant notes—for example, F#, C#, and D#—that give it the bell-like sound.

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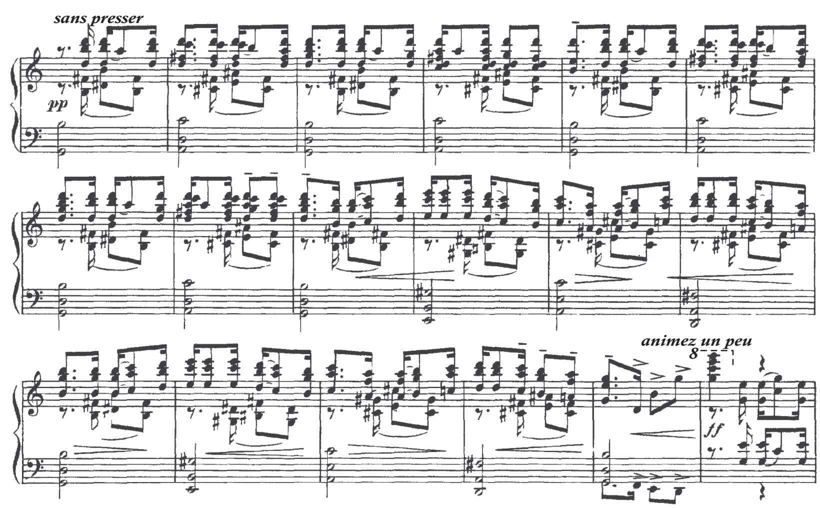

Correction

May 2015, page 36—The equation relating luminosity and effective temperature should be $L = 4\pi\sigma R^2 T_{\text{eff}}^4$. ■