Quantum physics for everyone

Julien Bobroff

With the help of designers and unconventional demonstrations, a group of French condensed-matter physicists set out to engage people who never thought of themselves as interested in science.

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For condensed-matter physicists, the year 2011 was a very special one. It marked the 100th anniversary of the discovery of superconductivity, one of the most fascinating topics in quantum physics and still one of the most studied. When certain materials—for example, aluminum and lead—are cooled to nearly absolute zero, they suddenly conduct electricity perfectly, with no resistance. Superconductors also expel magnetic fields, a property that causes magnets to levitate on top of superconductors. Even more fascinating, under certain conditions, the magnet becomes "pinned" to the superconductor. In that case, it can either levitate above the superconductor or remain suspended below it.

The superconductivity that kicks in at very low temperature was explained in the 1960s by John Bardeen, Leon Cooper, and J. Robert Schrieffer with what is now called the BCS model. However, more recently discovered families of superconductors conduct perfectly at temperatures up to 10 times that of the usual metals. The BCS model does not seem to apply to those high-temperature superconductors, hence the continuing research. Ultimately, physicists hope to discover a material that superconducts at room temperature.

As part of the centenary celebration, the French research agency CNRS asked researchers in the field to introduce superconductivity to the greater public. We were immediately enthusiastic, but two worries soon came to mind: Isn't quantum physics too complex to be explained to the general public? And in any case, are people really interested? Some public relations experts warned us that fundamental physics is not as appealing as it used to be. Now, they said, is the time to be talking about neurology or climatology. Interest in physics relates only to applications and new technologies.

Despite those warnings, we spent a year trying to show and explain superconductivity and quantum physics in a great variety of places and to all kinds of people—teenagers, younger children, students, parents, artists, journalists, and more. And we used all sorts of means, including websites, exhibits, movies, YouTube, live demonstrations, conferences, and science fairs. What we discovered was a surprise to most of us.

Bad news first

One lesson we learned was that if you stick to conventional outreach tools and actions, you will end up with a conventional outreach public, namely, people already interested in and familiar with science. We developed pedagogical exhibits and movies to explain superconductivity, a flyer, demonstrations, and even a website. Such content was useful for teachers and students in an academic setting, but it did not work that well for the general public. Our 10-panel exhibit with photos and images was a great decoration in science museums, science fairs, and school halls, but people did not actually spend time reading the content beyond the introductory panel. Our information-packed website attracts about 300 new visitors daily, but the average visiting time is less than 2 minutes. The 11-minute movie we made is just too long for people now used to YouTube videos. We realized too late that the internet has profoundly changed peoples' capacity to focus and read for more than a minute. Or perhaps people have long had a minuscule attention span.

A second bit of bad news is that outreach conferences do not reach a wide public. We organized many conferences all over France with well-trained, animated speakers who presented great slides and even live experiments. The rooms were often full of enthusiastic participants. But we discovered that the audience was mostly composed of the speakers' colleagues and their families, engineers, physics students, and retired scientists—essentially scientifically literate people already convinced of the importance of fundamental physics.

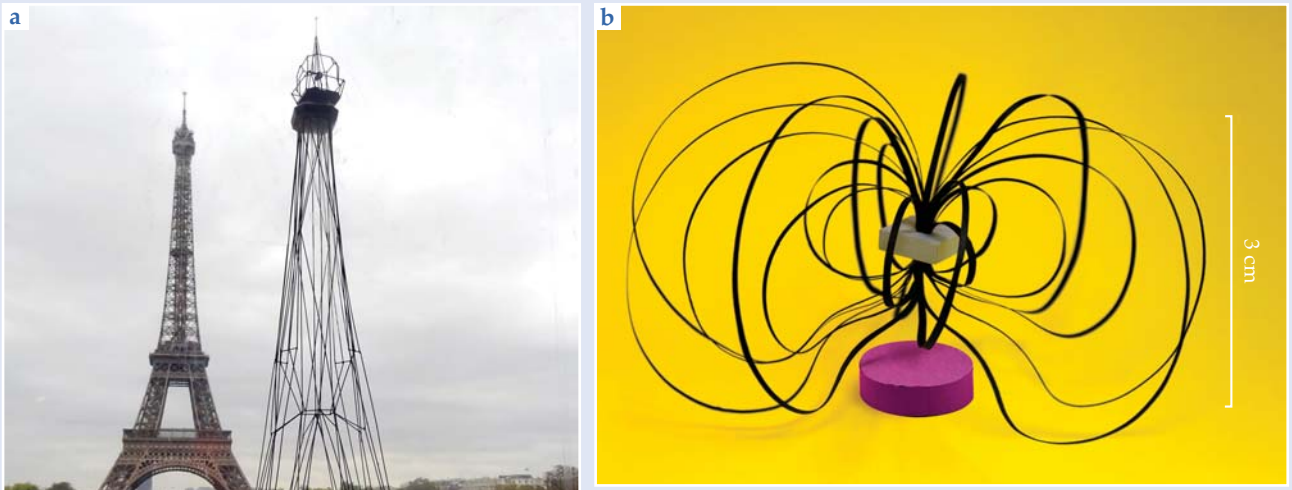
Ring in the new

Reaching the greater public demands new ways to engage—especially if the subject is quantum mechanics. Hence we tried new things. We went to new places: shopping malls, libraries, restaurants, and the heart of the city—for example, to Trocadéro square in front of the Eiffel Tower. At those places, we met people from all social backgrounds, not necessarily just those who attend science museums or science fairs. We developed new tools: captivating live experiments and activities to engage the public.

We could not create those new tools on our own; as scientists we tend to stick to pure and simple scientific experiments, with no distractions or embellishments. Thus we went to artists and designers and asked for their help. We did not just ask them to build things to our specifications though; rather, we collaborated with them to think outside the box and create new experiences based on our physics and their vision.

Together, we created an Eiffel Tower whose three floors could each be levitated with a combination of liquid nitrogen, superconductors, and magnets; we displayed our creation in front of the real Eiffel Tower, as shown in panel a of the figure. We also made superconducting games, mazes, sculptures, and even a circus where puppets levitate according to the laws of magnetism and superconductivity in a fun environment. Futuristic videos displayed levitating, superconducting jewelry and sportswear. Graphic designers helped us develop hands-on activities for kids—for example, folding activities that yielded a quantum wavefunction or, as shown in panel b of the figure, a levitating magnet with magnetic field lines. Colleagues at the Université Paris Diderot conceived a superconducting hoverboard that could be levitated above a magnetic railway; participants could "surf" on the board and then receive a "quantum levitation diploma."

Our new approach worked. The events we staged and the science fiction videos attracted a large, diverse audience. More than 200 000 visitors came to see live demonstrations in more than 20 cities in France; collectively, they met with



Innovative outreach. (a) From 18 October to 30 October 2011, visitors approaching the Eiffel Tower from Trocadéro square might have encountered a model in which each of three tower sections levitates above a superconducting ceramic. By bringing such displays to the heart of Paris, French physicists hoped to engage segments of the public not usually attracted by science outreach activities. **(b)** Artists and designers helped produce hands-on projects that introduce young people to quantum physics. In one such activity, children create the field of a magnet levitating above a superconductor.

hundreds of scientists and spent time hearing about the quantum world. We got most of the national French TV stations, radio stations, and newspapers talking about us.

The trick seems to be developing an appealing hook, such as "come and levitate on a quantum surfboard." Once we got people to come, everything was much easier than we anticipated. You can easily engage. The main questions people ask are not about applications or environmental impact, but instead are about the physics itself and about the researchers. We were constantly asked things like, What does "cold" mean? How does a superconductor levitate a magnet? What do you actually do in your work as a researcher? What are the great unsolved mysteries of physics? In our postevent follow-ups with, for example, high school students, most of the comments were about the researchers and the phenomena at play. Especially because of the public's interest in the conduct of physics, it is important that researchers be present at outreach demonstrations. They are not necessarily the best explainers of the physics, but they are the best suited to tell about work and life in the modern physics lab.

Going global

I do not claim that physics should be presented just as a way to have fun. In our events, once we gathered hundreds of people to watch the levitating Eiffel Tower, we told them about quantum physics for about 15 minutes or so. Moreover, we did not try to hide the complexity of the physics involved. But once a dialog had been initiated, people were willing to make the effort necessary to grasp a little bit of the quantum world.

Although not all physicists involved in outreach have received the same positive feedback that we and the other scientists who joined us have, we believe that the public is definitely curious about quantum phenomena and will approach the topic enthusiastically. Furthermore, whenever we have heard from physicists involved in innovative experiences such as Dan Dahlberg's Physics Force presented to Minnesota high schoolers or the EuroPhysicsFun shows presented all over Europe, the reports have been positive and inspiring. They also demonstrate that it is crucial to involve one's colleagues. That will not only make the experience more enjoyable, it will also make it easier to convince an institution to get involved and, in career evaluations, to acknowledge the individual's efforts as a legitimate contribution to the field.

During the past couple of years, we who worked on the centennial celebration have continued to develop our approach with a design project about quantum physics, three-dimensional animations, hands-on activities concerning famous discoveries, and so forth. But our work is just beginning. We now want to help create an international network of sharing and best-practice exchanges among researchers interested in outreach. We will have to gather and share. One crucial step will be to have innovations in a burgeoning "science of engagement" published in peer-reviewed scientific journals to complement works in the already established field of informal science education.

In the 21st century, the internet and new media have dramatically changed the way people discover, share, and learn. Amazing new tools are now available. As a result, the community of physicists needs to profoundly rethink its ways of engaging the public. Newcomers and new ideas are welcome!

Additional resources

- Physics Reimagined: New Ways to Present Modern Physics, http://www.physicsreimagined.com.
- Physics Circus, http://www.physicscircus.com.
- Quantum Made Simple, http://www.quantummadesimple.com.
- Supra2011 superconductivity webpage, http://www.superconductivity.eu.
- SupraDesign.fr, http://www.supradesign.fr.
- "The Eiffel Tower is levitating!", http://www.supraconductivite.fr/en/index.php#samuser-tour.
- MagSurf, the University of Paris 7 superconducting hoverboard, http://www.youtube.com/watch?v=_F-VVmMD4_k&feature=player_embedded. ■