INTERVIEW

Illustration by Shonagh Rae

“This is also a time of great possibility and great capability.”

Nobel Prize-winning astrophysicist Saul Perlmutter talks about how the scientific worldview leads to the ability to stick with a challenge, a willingness to be wrong, and—sometimes—the discovery of “amazing solutions to problems.”

Astrophysicist Saul Perlmutter is best known for his groundbreaking discovery that the expansion of the universe is accelerating—for which he shares the 2011 Nobel Prize in Physics. But Perlmutter, a professor of physics at the University of California, Berkeley, and senior scientist at Lawrence Berkeley National Laboratory, has also thought deeply about the nature of science and how it can be employed to advance society. A new book he coauthored with philosopher John Campbell and social psychologist Robert MacCoun, *Third Millennium Thinking: Creating Sense in a World of Nonsense*, explores how the tools and frameworks that scientists use "to stop us from fooling ourselves" can help improve decisionmaking and problem-solving more broadly. In addition, as a member of the National Academy of Sciences and the President's Council of Advisors in Science and Technology (PCAST), he has a unique view into how science policy is shaped. In an interview with *Issues* contributing editor Molly Galvin, he discusses how physics and music inform each other, how the culture of science encourages sticking with problems, and the sources of his optimism.

What has playing the violin taught you about science?

Perlmutter: Well, science is such a social activity. I was always interested in chamber music, not just playing music by myself, and I was looking for that interaction in science. I've tended to gravitate toward working with people. Nowadays, that's a lot of what experimental science, especially physics, has become. I think music played a big role in teaching me what happens when a group's working really well together. When I first started at Berkeley as a faculty member, I was asked to teach the Physics and Music course. At first I thought it would be the most boring parts of physics meet the most boring parts of music, but by the end of planning the course I realized that you can teach a whole lot of really fundamental aspects of how you think about the world, using music as the way in. I did a lecture the last day of the course in which I gave them what we now know about cosmology using all these tools of thinking that we had developed over the course of studying music. And I realized that you get a much more sophisticated understanding of what it is that we're doing in cosmology by using the physics concepts taught to understand music.

You spent a decade doing the research that led to your Nobel Prize. What was that like for you?

Perlmutter: We had set out to find out how much the expansion of the universe was slowing down due to gravity, because that was the big key question. Do we live in a universe that will last forever, and do we live in a space that's infinite? Or is it curved in on itself? These are fun, almost philosophical questions.

We knew it was going to be a hard project. We thought it would take three years. Three years in, we appeared to have gotten nowhere. We had only learned pieces of how we would solve the problem. But every step along the way, you could see how what we'd done so far was actually starting to consolidate understanding of what it was going to take to get where you wanted to go. We had a sense that this was a solvable problem, and that it was so important that it was really worth sticking with.

About five to six years in, we started figuring out how to turn this difficult problem into a repeatable solution. Over the next three or more years, we were just doing the operations we'd figured out how to do—collecting the dataset—and the last year was analyzing the data. It wasn't until nine years in that we started seeing results that were shocking. Discovering that the expansion of the universe was, in fact, accelerating was the opposite of what we expected to be measuring—and that's in some sense even better, because now there's something new about physics that we hadn't appreciated.

One of the things I learned as a graduate student was how the culture of science allows for sticking with problems much longer than most humans would ordinarily. It encourages you to ask, "Is this problem, in principle, solvable? Are we getting closer to solving it?"

You have said that the life of a scientist revolves around making mistakes and trying to fix them. How do you think that experience has shaped your worldview?

Perlmutter: Having that bit of diabolical contrariness is a weird pleasure of being a scientist. You're always trying to figure out, "OK, how could I be fooling myself into a wrong conclusion?" Because the more you get those things right, the more chances you have of catching the universe doing something that our brains never would've imagined.

Scientists build out of what *seems* like a stance of weakness. So, one might think it's terrible that scientists are always discovering new ways that they're wrong, or it's terrible that they're only probabilistically sure of facts. But that's really where scientists' superpower has come from. We have been able to figure out amazing solutions to problems or surprises about the world. Much of that can be traced back to being willing to be wrong and being comfortable with finding the ways you're wrong. And for this purpose, you want to build strong relationships with people who are going to tell you when you're wrong, who will disagree with you, or who compete with you. They're your best bet at figuring out where you're making a mistake.

You work on theories of expansion of the universe and dark energy. Working in this community of cosmologists, do you have a theory of how people's minds change?

Perlmutter: I don't think I have an articulated theory of change. But I will say that I've been really interested to watch fairly dramatic changes happen in my own field. When I started, physicists were seen almost like carpetbaggers coming into the astronomy world. Now, for many of the big projects, the astrophysicists from the physics department and those from the astronomy department are seamlessly integrated.

Individuals and small groups were always building their own analyses, and some open-source advocates were arguing that we needed to be able to share things more. I was pushing for that very strongly too—and then recently I find myself in the funny position of realizing that as a community we've been so successful at this that we've ended up in a world where sometimes everybody's all in the same group, and we aren't getting enough voices pushing against each other. We always said we should make sure the software is seamless and open so everybody can use it. But once you get to the point that there is a dominant software that everybody's using, it's much harder to check to make sure that it doesn't have bugs in it. You can, but it's dramatically more difficult because you don't have several competing codes that have to be in agreement.

One of the lessons from teaching the Sense & Sensibility & Science class at Berkeley and writing our new book, which came out of that curriculum, is that we keep learning new ways in which we fool ourselves and we keep learning new ways to do better. Maybe that is what science is—that constant ability to keep watching ourselves and improving our approaches to understanding the world.

For example, it's only in recent decades that particle physicists started seeing evidence that a form of confirmation bias was affecting their measurement results, when scientists would stop looking for additional sources of error or additional computer bugs when they got the results that they expected to see. This has led to a new practice (called "blind analysis") of hiding the results while hunting for errors and bugs. It's now becoming a standard approach in cosmology measurements, too, and other fields of science are developing parallel methodologies.

You started teaching Sense & Sensibility & Science more than a decade ago. As a physicist, why did you get interested in teaching about better communication and decisionmaking?

Perlmutter: So 10 or 15 years ago, I would go to the lunch table with a bunch of scientists from the lab and they'd be talking about the politics of the day. But the conversations at the lunch table sounded so different from what you see in the newspapers. People were just using a whole different vocabulary of ideas. And I kept thinking, "Where do we learn all those ideas?"

It was pretty clear that they were not taught in any physics, biology, or chemistry course that I ever took—they were taught mostly by apprenticeship as people went through PhDs and postdocs. The scientific culture was teaching these ideas to students as part of that experience.

So when Berkeley announced a new kind of course called "Big Ideas Courses" to work across disciplines, I thought, this is exactly the time to teach a course like this. Because the parts that I was already starting to think about, which I understood from training as a physicist, were not the whole story. A lot of the elements are coming from social psychology and what we've learned about group and individual dynamics in decisionmaking. Some of these things are actually philosophical questions: How do you want groups to be able to weigh priorities and values amidst the rational techniques that we're teaching?

In other words, if you're going to try to teach people how to think rationally, then you also have to ask how you're going to weave that in with people's values and fears and goals and emotions. Because the fears and goals and emotions are the things that drive decisionmaking at the end of the day.

Are there certain models or mechanisms that help people find a balance between scientific information, values, goals, and fears?

Perlmutter: One model that I thought was particularly exciting to watch is deliberative polling—the technique where you bring together a truly representative sample of the population—which is used by some citizen assemblies. It has to be randomly sampled, so that basically everybody will be in that microcosm. And they don't just vote. The group starts to deliberate, with experts available, ideally from all sides of an issue, who answer questions and help them think through the problems in an informed, thoughtful way. And then after many hours of this, they start to home in on some views. Because they are a true representative sample, they represent the values of the broader population. So the resulting views should reflect the values of the people when well informed.

In the end, you see some really nice policies and results that have come out of that kind of process. In some countries, this is becoming a part of how the government works.

Has being a member of PCAST changed your thinking about how regulating or policymaking is done?

Perlmutter: Every time I've worked with government, either the legislative branch or in this case the executive branch, I'm reminded of how difficult it is to make progress because so many parts have to come together. But at the same time, you can make a difference. Anything you recommend is unlikely to be instantaneously effective—it may be that a number of years go by until people really absorb it and try and figure out how to use it.

For example, one of the earlier PCASTs recommended that hearing aids be made more of a commodity by taking it out of

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this specialized system of control and making it something that you can buy much more conveniently. And that ended up recently getting enacted. I'm assuming that pretty much all of us will at some point be using hearing aids.

What do you think scientists don't understand about policymaking?

Perlmutter: The more that scientists have a chance to spend time with legislators and people in the other branches of government, the more they will be aware of the different ways in which people need to receive information. It isn't just a matter of saying, "Here's the answer," but giving them insight into how the answer was reached and why they might come to that same conclusion.

I think we're in a bad period for political figures themselves to act as the thought leaders. I don't fault them, because if you're a congressman, for example, you're in a very tricky position to take on a new idea and then convince everybody to adopt it—especially if it goes against the orthodoxy of whatever party you're in.

As scientists, we have an extra responsibility now to try to work harder to communicate about what we are doing. Scientists should try to spend time with the public before sending ideas or advice to legislators and executive branch members and agencies. That's not something we've typically done because we're very busy, like everybody. But I think there's enough of a pleasure in it that scientists could feel that it was a good use of their time. That's my secret hope.

You worked on some recent National Academies guidance on how to responsibly incorporate artificial intelligence into science. How do you see AI being used in cosmology?

Perlmutter: We've already been using many of the earlier versions of AI in cosmology, with new techniques using mathematics and statistical analysis. But the current version that got so much attention this past year—generative AI—raises a whole bunch of other ideas.

I think it'll speed our ability to talk across the subdisciplines. And that by itself may be very interesting for the sciences. We're already using it in computer programming. I find myself programming in computer languages that I probably would not have bothered with if it weren't for the fact that I can ask AI for help.

What are your concerns about how AI might be used in science?

Perlmutter: My concerns fall into the category of what happens when we automate anything. AI clearly provides many more opportunities and expectations for automation. However, all the safety engineering that you would do if you were designing a braking system for a car—we haven't always done that to the same degree for automation.

We need to step back and ask, "Have we done the right due diligence? How could this automation go wrong? What are our indicators that it's going wrong? And what are the fail-safes to make sure that we catch it if it does go wrong? Have we come up with the right fallbacks?"

You talk a lot about problem-solving, both as a scientist and as a citizen of the world. But let's be realistic—we are facing some overwhelming problems as a society right now. What do you anticipate for the future?

Perlmutter: If we can at least partially heal our fractured society, then I would not be that worried about the huge problems of the world. We've demonstrated in just our own lifetime that we can take on gigantic problems that we never thought we could take on.

Much of the world was going to bed hungry when I was a child. But over the course of the last 50 years, percent by percent, we've brought the number of people who are chronically hungry down to 10%. And we never thought that that was possible (though progress isn't always linear, and this number recently rose slightly).

We know now that we are capable of solving problems on this scale. But I think it only happens when people are really working well together. Right now, we walked ourselves into a bit of a dark corner where people aren't collaborating with each other in a positive way. But if we just turn that corner, then I think we're in an amazing position. We actually could be making a world to live in that everybody would feel proud of.

And people should be aware of this, that this isn't simply a catastrophic time in history. This is also a time of great possibility and great capability that we've never had in front of us before. The *Bulletin of the Atomic Scientists* has this doomsday clock with the "minutes to midnight." I keep saying that we need, on that same page, the "minutes to noon" clock—because I think we are remarkably close to being able to make a world that everybody would feel wonderful about living in.