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FAR FROM THE FRONTIER

Ignoring the mainstream, physicist Seth Putterman has a knack for bringing long-forgotten mysteries back to the fore. **Geoff Brumfiel** discovers some of the payoffs, and perils, of being a fiercely independent researcher.

Lawrence Crum thought the experiment was cute; Seth Putterman thought it was miraculous. The year was 1989, and Putterman, a theoretical physicist at the University of California, Los Angeles, (UCLA) was visiting Crum's laboratory at the University of Mississippi in Oxford. One of Crum's graduate students, Felipe Gaitan, was exploring an unusual phenomenon: the creation of light from sound. He began with a glass cylinder filled with a water and glycerine mixture. By vibrating the cylinder at a low frequency, he could create a single bubble that would rhythmically expand and collapse, releasing a tiny flash of light as it did so.

Putterman took one look at a video recording of the flashing bubble suspended in the tube and became feverish. "You shouldn't be able to do it," he remembers thinking. "The energy of a piece of sound is 12 orders of magnitude smaller than the energy of a piece of light." Putterman begged Crum to carry out more experiments on the little bubble. How did it form? Why was it so stable? Where did the energy for those light flashes come from?

But Crum had other priorities, not least securing adequate funding for the 150 people then working on physical acoustics in Mississippi. The technical term for what Crum's graduate student had seen was sonoluminescence, and it was nothing new — physicists had known about it for at least 60 years. In 1989 sonoluminescence was not a particularly hot topic. Crum shrugged off Putterman's interest, saying if he wanted to study the little flashing bubble, he was welcome to go ahead and try.

Theoretical physicists spend most of their time at their desks, so perhaps Crum didn't expect Putterman to take up the offer. But back in California the theorist quickly set up his own experiment to recreate the Mississippi effect. He then followed a recipe that has often served him well since: he used precise instrumentation to characterize the phenomenon in detail, and applied a theoretical understanding that was strong enough to challenge popular models of the time.

Within two years Putterman had some surprising results[1]. The inside of the bubble was imploding faster than anyone had thought, and the temperature at its core seemed shockingly high — perhaps five times that of the surface of the Sun. Overnight, sonoluminescence became a cottage industry in the world of acoustical physics. Everyone wanted to know what made it tick.

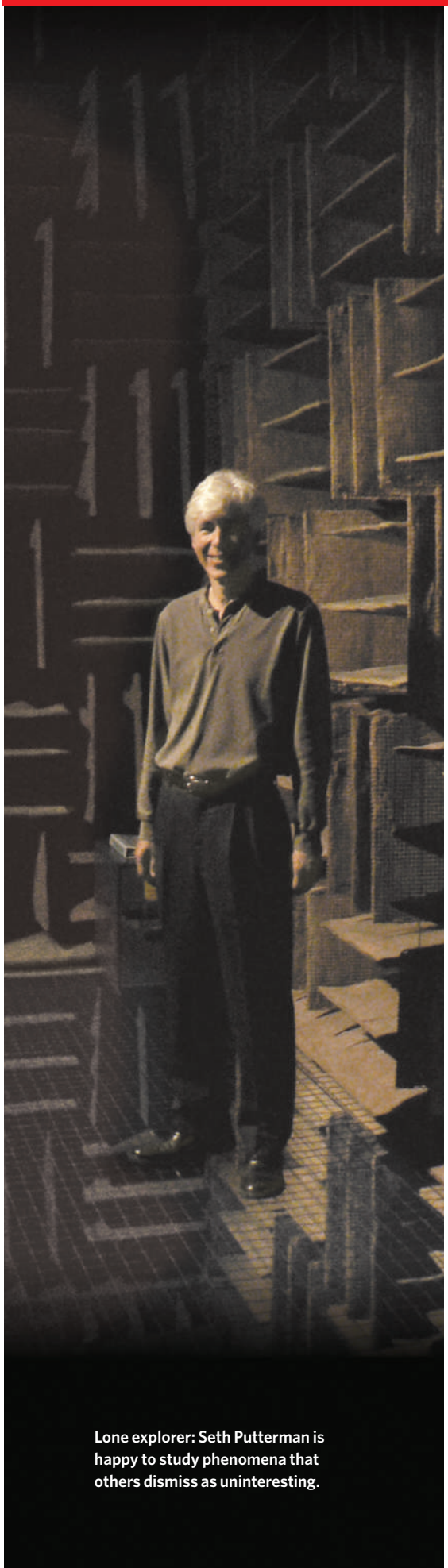
"Seth Putterman is sure of himself, enthusiastic, smart, thinks fast on his feet — and he can be abrasive as hell." — Kenneth Suslick

Now 59 years old, Putterman is tall and skinny with a deep Californian tan and a shock of bright, silver hair. Among friends and foes alike, he is known for his love of physics, his penchant for controversy, and his fierce independence. In an era when much of physics advances through the cooperative efforts of hundreds of researchers, Putterman is a lone figure willing to study any phenomenon, no matter how obscure, and ready to publicly take on his critics, no matter how impolitic.

Bright spark

Aside from physics, Putterman loves good wine, and over a bottle of 2001 Killibinbin Shiraz, he recalls his beginnings in science. From an early age, he found himself gravitating towards physics; he studied the subject first at Cooper Union in New York, and later at the California Institute of Technology (Caltech) in Pasadena, where he completed his undergraduate degree in 1966.

Even in those early days, Putterman was unafraid to snub convention. His first grant proposal was drafted to support his love for wine-tasting, not physics. Under the 1958 National Defense Education Act, which encouraged US students to pursue careers in science, Putterman was eligible for a low-interest loan. The government was persuaded by Putterman's argument that although he was sure he wanted to embark on a career in physics, he felt a hobby would help keep him going. "Caltech was very supportive of my



Lone explorer: Seth Putterman is happy to study phenomena that others dismiss as uninteresting.

proposal," Putterman recalls. "I got US$2,000, which went a long way to buying great Bordeauxs like a 1959 Lafite and 1959 Yquem!"

After graduating from Caltech, Putterman returned to New York City to attend Rockefeller University, where he studied under George Uhlenbeck, who together with Samuel Goudsmit, discovered electron spin in 1925. Uhlenbeck was a kindred spirit, a man who loved physics and had little patience for the politics of the field. "He had no concern about what was or wasn't the official frontier of physics," Putterman reflects.

Burst bubble

But his adviser could also be intimidating. On Saturday mornings, Putterman would often find Uhlenbeck in his office, smoking a cigar and meditating in a large leather-backed chair. "I would tell him some scientific insight I'd had in the last week, and he would go over it, see what it meant, formulate it, work with it, attack it — but he'd be enjoying it the whole time," Putterman says.

Putterman cherishes his cloistered days at Rockefeller University, but admits that they left him unprepared for the realities of modern science. "I was totally sheltered at the Rockefeller," he says. The faculty didn't have to get funding, and Uhlenbeck never discussed university politics with him.

But at least Rockefeller gave him the strength and independence to pursue his own interests, he says. He never worries about 'frontier science', as he calls it, even asking his students to replicate a 300-year-old experiment whose results were never explained. In the case of sonoluminescence, this strategy propelled Putterman to celebrity status. But it has also led his critics to accuse him of profiting from recycled ideas. "On a grant proposal I once wrote, I was accused of being a used-car salesman," he says with a chuckle. "But I think there's just wonderful stuff in the old literature waiting to be exploited with modern instrumentation."

Putterman also likes a good fight, and he is never afraid to publicly take on his critics. "He is sure of himself, enthusiastic, smart, thinks fast on his feet — and he can be abrasive as hell," says Kenneth Suslick, a chemist at the University of Illinois at Urbana–Champaign. Putterman has clashed repeatedly with other scientists over interpretations of his first sonoluminescence experiments. Putterman firmly believes that the flash at the centre of the bubble is created by electrons being shaken out of their atomic orbits, whereas his opponents suspect more conventional chemistry is the culprit. The debate has turned so acrimonious that some of his opponents refused to speak to *Nature* for this article.

Although Putterman is upset by some of the personal disputes that his work has sparked, overall he remains unfazed by funding difficulties and academic controversy. And true to form, earlier this year, his latest experiments[2] landed him in the centre of another political tussle.

In his lab at UCLA, Putterman shows off his latest marvel, a crystal just a few centimetres long; when the crystal is heated, an enormous electric charge builds up on its surface. Like so many of the phenomena studied by Putterman, this type of crystal is not new — it was first described by the Greek philosopher Theophrastus in 314 BC. But Putterman is the first to exploit its properties for nuclear fusion.

Putterman is using the crystal's electric field to catapult hydrogen ions onto a hydrogen-filled target. The result is the fusion of nuclei, which produces helium, and a flurry of neutrons. What is surprising is that this tabletop experiment generates the sort of fusion event that usually requires heavy-duty particle accelerators.

Desktop fusion

The problem with reports of tabletop fusion is that for most scientists they evoke memories of the notorious, and now largely discredited, 'cold fusion' claim made by two chemists in 1989. The chemists claimed they could achieve nuclear fusion reactions well below the extreme temperatures predicted by theorists, and that these reactions could be used as a source of unlimited energy.

Perhaps unsurprisingly, the press were quick to label Putterman's recent findings using the crystal[2] as 'cold fusion'. Many scientists might have been horrified to have their research mischaracterized in this way, but Putterman was unperturbed by the controversy, and even enjoyed it. "If people think this is a crackpot paper that's just fine," he told *Nature* at the time of his group's announcement. "We're right." In the end, researchers found Putterman's measurements of the fusion reactions convincing, and Putterman is now planning to develop commercial and medical applications of his work.

Despite turning 60 this year, it seems unlikely that Putterman will narrow his eclectic pursuit of physics. These days, some of his students are attempting to back up the unconfirmed claim that sonoluminescent bubbles are powerful enough to be used as a form of tabletop 'bubble fusion'[3]. Another team is starting to make precise measurements related to the randomness inherent in quantum mechanics. It's an area that has long tickled his fancy, although he knows little about it.

During his long career, Putterman has picked up no society awards, and funding has often been tight, but he continues to be driven by the challenge of science itself. "I don't do physics with the goal of scoring grant money or proving myself; I do it for the fun of learning something new," he reflects. ■

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1. Barber, B. P. & Putterman, S. J. *Nature* **352,** 318–320 (1991).
2. Naranjo, B. *et al. Nature* **434,** 1115–1117 (2005).
3. Taleyarkhan, R. P. *et al. Science* **295,** 1868–1873 (2002).