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Jean Bourgain, Problem-Conquering Mathematician, Is Dead at 64

By Kenneth Chang

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Jean Bourgain, a mathematician who conquered difficult problems prolifically across a wide swath of fields, died on Dec. 22 at a hospital in Bonheiden, Belgium. He was 64.

The Institute for Advanced Study in Princeton, N.J., where Dr. Bourgain was a professor, said the cause was pancreatic cancer.

Dr. Bourgain's honors included a Fields Medal in 1994, perhaps the most prestigious prize in mathematics, and the 2017 Breakthrough Prize, which was accompanied by $3 million. That prize, whose sponsors include Mark Zuckerberg, the founder of Facebook, and Sergey Brin, a founder of Google, attempts to bring popular attention to researchers at the cutting edge of science and mathematics.

Dr. Bourgain wrote or co-wrote more than 500 papers, far more than most professional mathematicians.

"He was a problem solver unequaled," Peter C. Sarnak, a colleague of Dr. Bourgain's at the institute, said in an interview.

Dr. Sarnak said that Bourgain started out in an esoteric corner of mathematics with extremely difficult problems. "He just came in and started solving one problem after the other in that subject," he said. "So he made his name there, became very famous, winning all sorts of young-up-and-coming-star prizes. But then he broadened out."

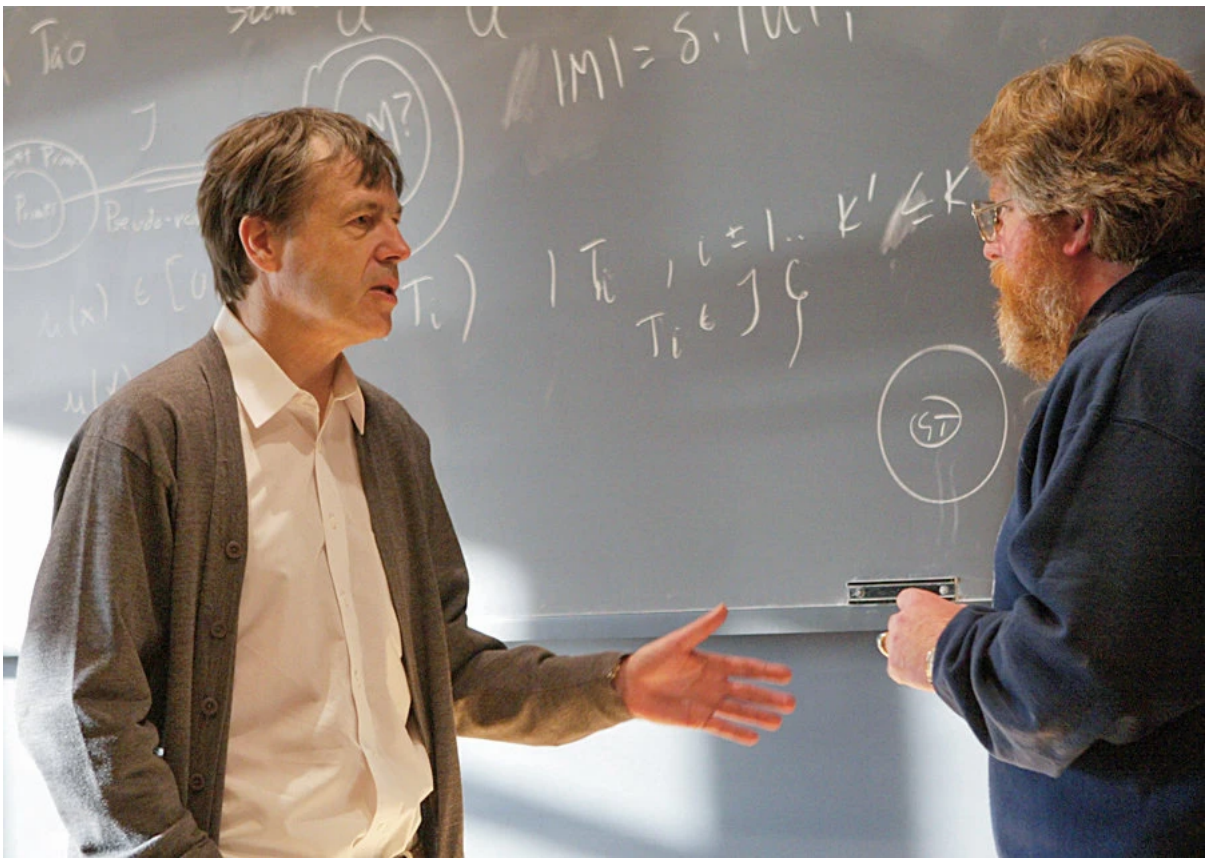
Dr. Bourgain found that tools he had developed could also be applied to other fields of mathematics, including partial differential equations, computer science, quantum mechanics and dynamical systems, making progress on formidable problems that had stymied experts in those areas.

"There would be some big mountain in front of you," Dr. Sarnak said, "and he would ascend halfway up, occasionally all the way up. People couldn't understand how he got all the way up. It would take often months or years for people to understand his proofs. He liked the idea that he was way ahead and people were catching up to him all the time. He would open these doors."

Some of Dr. Bourgain's recent work included a "decoupling theorem" — a very abstract generalization of the Pythagorean theorem applied to oscillating waves, like light or radio waves. While Pythagoras merely showed how the length of the two shorter sides of a right triangle are related to the longer hypotenuse, the decoupling theorem proved by Dr. Bourgain and Ciprian Demeter, of Indiana University, showed similar relationships in the superposition of waves, when the individual oscillations are added together.

The Belgian government bestowed the title of baron on Dr. Bourgain in 2015. He designed a coat of arms for himself with the inscription "In spem contra spem," or "In hope against hope."

Jean Bourgain was born on Feb. 28, 1954, in Ostende, Belgium. After receiving a doctorate from the Free University of Brussels in 1977, he became a professor at the university in 1981.



Dr. Bourgain, left, in 2010 at the Institute for Advanced Study in Princeton, N.J., with Russell Impagliazzo, who is now a professor of computer science at the University of California, San Diego. Andrea Kane/Institute for Advanced Study

In 1985, he began splitting time between the University of Illinois at Urbana-Champaign and the Institut des Hautes Études Scientifiques in Paris. He was also a professor at the Hebrew University of Jerusalem and the California Institute of Technology before moving to the Institute for Advanced Study in 1994.

Dr. Bourgain worked in the area of mathematics known as analysis, which often studies inequalities, with the aim of trying to simplify problems instead of coming up with exact solutions. “The art of analysis is not to lose the important information,” Vitali Milman, a mathematician at Tel-Aviv University in Israel, said in a phone interview.

Dr. Milman recalled that he and Dr. Bourgain were once discussing a math problem and Dr. Bourgain told him that he had always kept two problems in mind: “One which I want to solve and another which I can solve.”

When Dr. Bourgain was stuck on the problem he was working on, Dr. Milman said, he would work through the other one — which he knew how to work through — to reassure himself that he had not become “impotent in mathematics.”

What was amazing, Dr. Milman said, was that Dr. Bourgain could intuit that a problem was solvable: “He was ready to do it, before he actually knew how to do it.”

Dr. Bourgain was less comfortable in the classroom. While teaching a course at Illinois, he once asked Dr. Milman to join him on campus to provide emotional support. Before a lecture Dr. Bourgain was to give, Dr. Milman noticed him looking at a piece of paper. Dr. Milman asked if he was doing last-minute preparations. No, Dr. Bourgain replied; he was calculating what he would earn for holding the class.

“When I see the number,” he told Dr. Milman, “I feel at ease going to the lecture.”

Dr. Bourgain’s cancer was diagnosed in late 2014, but he continued his math research.

Larry Guth, a mathematician at the Massachusetts Institute of Technology, recalled coming across the decoupling theorem by Dr. Bourgain and Dr. Demeter. Their proof went against the expectations of people in the field. “That made me very curious about it,” Dr. Guth said in an interview.

But Dr. Guth was hesitant to contact Dr. Bourgain, who had undergone cancer surgery a few months earlier. Then he checked an online archive of mathematics papers and found that Dr. Bourgain had posted several new papers since his operation.

Dr. Guth wrote to Dr. Bourgain and Dr. Demeter, and they began discussing how to extend the work. A couple of weeks later, Dr. Guth was visiting Princeton and went to visit Dr. Bourgain, who then explained how to solve the problem they had been discussing. “It filled 10 blackboards,” Dr. Guth said.

The resulting paper used the superposition of waves to settle a question about integers — a problem that had been intractable for more than 80 years.

Dr. Bourgain is survived by his wife, Mei-Chu Chang; a son, Eric; and a sister, Claire Bourgain.

A year ago, the American Mathematical Society honored Dr. Bourgain with its Steele Prize for lifetime achievement, but he was not done.

In November, he was finishing a few final projects. Dr. Milman said a journal he edits will publish one of Dr. Bourgain's final papers next month.

Correction: *January 16, 2019*
A picture caption with an earlier version of this obituary misspelled the given name of one of the men pictured with Dr. Bourgain. He is Sundar Pichai, not Sunda.

A version of this article appears in print on Jan. 18, 2019, on Page A20 of the New York edition with the headline: Jean Bourgain, 64, a Mathematician Known as a 'Problem Solver Unequaled'