

# *Isadore Singer, Who Bridged a Gulf From Math to Physics, Dies at 96*

His unifying disparate theoretical realms helped revolutionize our understanding of the most basic structure of the universe.

**By Julie Rehmeyer**

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Isadore Singer, who unified large areas of mathematics and physics in becoming one of the most important mathematicians of his era, died on Thursday at his home in Boxborough, Mass. He was 96.

His death was confirmed by his daughter Natasha Singer.

Dr. Singer created a bridge between two seemingly unrelated areas of mathematics and then used it to build a further bridge, into theoretical physics. The achievement created the foundation for a blossoming of mathematical physics unseen since the time of Isaac Newton and Gottfried Wilhelm Leibniz, when calculus first provided tools to understand how objects moved and changed.

Dr. Singer's work with the British mathematician Michael Atiyah allowed for the development of critical areas of physics, like gauge theory and string theory, that have the potential to revolutionize our understanding of the most basic structure of the universe.

He “changed how people viewed mathematics by showing that seemingly different areas have deep connections,” said Jeff Cheeger, a mathematician at New York University.

“It opened up a whole new world that’s expanded and expanded,” he said.

Dr. Singer was an influential voice in scientific matters outside the theoretical realm as well. From 1975 to 1980 he was chairman of the Committee on Science and Public Policy at the National Academy of Sciences, the most important scientific advisory committee for the president and other government officials.

In that post, he organized a report on the disposal of nuclear waste, defended President Ronald Reagan’s “Star Wars” missile defense initiative despite being politically opposed to many Reagan policies, and, decades before it became a pressing public issue, warned about the loss of privacy with the growth of the internet.

Under Reagan, he was a member of the White House Science Council from 1982 to 1988, and from 1995 to 1999 he was on the governing board of the National Research Council.

Dr. Singer was awarded the National Medal of Science in 1983 and the Abel Prize in 2004, often considered the Nobel of mathematics.



Dr. Singer, left, and Michael Atiyah, center, receive the Abel Award from King Harald of Norway in Oslo in 2004. The prize is considered the Nobel of mathematics. Knut Falch/Associated Press

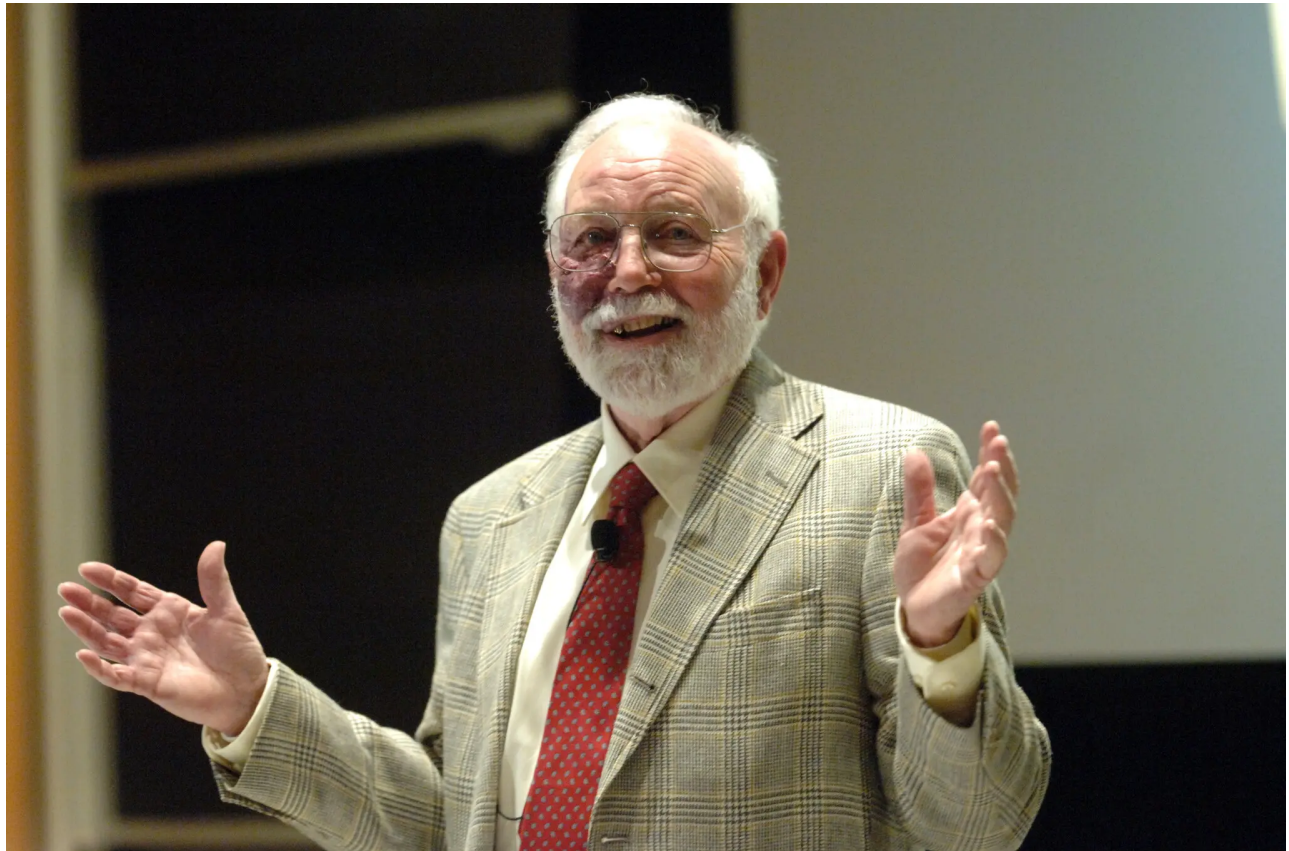
Isadore Manuel Singer — known to his friends as Is — was born on May 3, 1924, in Detroit to Simon and Freda Singer, immigrants from Poland. His father, who spoke only Yiddish, was a printer; his mother was a seamstress. Isadore quickly learned English and taught his family the language. His brother, Sidney, went on to become a particle physicist at Los Alamos National Laboratory in New Mexico. (He died in 2016.)

Isadore studied physics at the University of Michigan, graduating in two and a half years in order to join the Army as a radar officer during World War II. Stationed in the Philippines, he ran a communications school for the Filipino Army during the day. At night, he filled in the gaps of his abbreviated education, studying mathematics in correspondence courses to learn the prerequisites for relativity and quantum mechanics.

After leaving the Army, he spent a year studying math at the University of Chicago. Though he had planned to return to physics, he fell in love with mathematics and stayed to earn his doctorate. He did a postdoctoral fellowship at the Massachusetts Institute of Technology, where he ended up teaching for almost his entire career.

During an interlude at the University of California, Berkeley, he helped found the Mathematical Sciences Research Institute. He also began proving a number of important theorems, leaving mathematics literature peppered with his name: the Kadison-Singer conjecture (formulated in 1959 and proved only in 2013), the Ambrose-Singer theorem, the McKean-Singer formula and Ray-Singer torsion.

But all those were dwarfed by his singular contribution, the Atiyah-Singer Index theorem. Together with Dr. Atiyah, he created an unimagined link between the mathematical subfields of analysis and topology — and then united those fields with theoretical physics.



Dr. Singer delivering a lecture in 2006. A weekly seminar he held for decades became a breeding ground for new ideas. Donna Coveney

Dr. Singer was the expert in analysis, which is the study of differential equations, used to describe physical phenomena in the language of calculus. Such equations are extremely useful for describing real-world situations, but they have a problem: No one knows how to solve them precisely. Scientists are stuck with approximation.

Dr. Atiyah, meanwhile, specialized in topology, which studies the shapes of abstract mathematical objects, often in many more dimensions than our ordinary three. Topology considers shapes to be elastic, so that objects can be pulled or squished without changing their fundamental nature.

The two fields seemed to be nearly irremediably divided, because topology twists objects around, and analysis needs them to be rigid. Nevertheless, in the early 1960s, Dr. Singer and Dr. Atiyah sought to figure out if Dr. Atiyah's topological tools could find solutions to analytical problems Dr. Singer was having with differential equations.

Finding the exact solutions was too hard. But they found a way to figure out the number of solutions to the equations, even without their exact values. This was the Atiyah-Singer Index theorem.

The result created a bridge between topology and analysis that Dr. Atiyah, Dr. Singer and others widened and built upon over the next decade, creating a new field called index theory.

That was just the beginning. In 1975, James H. Simons, a mathematician and a close collaborator with Dr. Singer (and later a prominent hedge fund manager and philanthropist), and Chen Ning Yang, a Nobel-winning physicist, were

discussing their work. They realized that in their own scientific languages they were each talking about a common underlying structure. What the physicists called a “gauge theory” was what the mathematicians called a “fiber bundle.”

Through this connection, the Atiyah-Singer Index theorem applied to physics just as it did to mathematics. The revolution it had brought to mathematics now carried over to physics, too.

“This was the Big Bang of late 20th century unification between mathematics and physics,” said the mathematician and economist Eric Weinstein. “It was Is Singer who lit the spark that caused the fire.”

Dr. Singer’s first marriage, to Sheila Ruff, a play therapist for children with disabilities, ended in divorce. In addition to his daughter Natasha, a technology reporter for The New York Times, he is survived by his wife, Rosemarie Singer; three other children, Eliot, Emily and Annabelle; two stepchildren, Giles and Melissa; and four grandchildren.

Dr. Singer came to stand at the intellectual center of developments in mathematical physics. A weekly seminar he held for decades became a breeding ground for new ideas, perhaps befitting a man who blazed new paths in his chosen field and resisted conforming to the dry image of a scholar and academic.

“He drove a sports car when everyone else drove a Volvo,” Dr. Weinstein said.

“He showed up with a cravat when no one wore neck gear.”

He added, “He had a very romantic vision of living life to the fullest through math, with style and panache, and he wielded his taste and style as a tool in mathematics like no one else.”