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SCIENTIST AT WORK: SHING-TUNG YAU

The Emperor of Math

By DENNIS OVERBYE

In 1979, Shing-Tung Yau, then a mathematician at the Institute for Advanced Study in Princeton, was visiting China and asked the authorities for permission to visit his birthplace, Shantou, a mountain town in Guangdong Province.

At first they refused, saying the town was not on the map. Finally, after more delays and excuses, Dr. Yau found himself being driven on a fresh dirt road through farm fields to his hometown, where the citizens slaughtered a cow to celebrate his homecoming. Only long after he left did Dr. Yau learn that the road had been built for his visit.

“I was truly amazed,” Dr. Yau said recently, smiling sheepishly. “I feel guilty that this happened.” He was standing in the airy frosted-glass light of his office in the Morningside Center of Mathematics, one of three math institutes he has founded in China.

For nine months of the year, Dr. Yau is a Harvard math professor, best known for inventing the mathematical structures known as Calabi-Yau spaces that underlie string theory, the supposed “theory of everything.” In 1982 he won a Fields Medal, the mathematics equivalent of a Nobel Prize. Dr. Yau can be found holding court in the Yenching restaurant in Harvard Square or off the math library in his cramped office, where the blackboard is covered with equations and sketches of artfully chopped-up doughnuts.

But the other three months he is what his friend Andrew Strominger, a Harvard physicist, called “the emperor ascendant of Chinese science,” one of the most prominent of the “overseas Chinese” who return home every summer to work, teach, lobby, inspire and feud like warlords in an effort to advance world-class science in China.

David J. Gross, the Nobel physicist and string theorist who directs the Kavli Institute for Theoretical Physics in Santa Barbara, called Dr. Yau “a transitional figure, between emperor and democrat.”

Dr. Yau’s story is a window into the dynamics that prevail in China as 5,000 years of Middle Kingdom tradition tries to mix with postmodern science, a blending that, if it takes, could eventually reshape the balance of science and technology in the world.

“In China he is a movie star,” said Ronnie Chan, a Hong Kong real estate developer and an old friend who helped bankroll the Morningside Center. And last summer Dr. Yau played the part, dashing in black cars from television studios to V.I.P. receptions in forbidden gardens in the Forbidden City. He ushered Stephen Hawking into the Great Hall of the People in Tiananmen Square to kick off a meeting of some of the world’s leading physicists on string theory, and beamed as a poem he had written was performed by a music professor on the conference stage. It reads in part: “Beautiful indeed/is the source of truth./To measure the changes of time and space/the smartest

are nothing."

Dr. Yau does not buy the emperor bit. Where, he protested recently, is his empire if he holds no political position and two of his most brilliant recent students are currently without jobs? "It's just a perception as far as I can tell," he said.

Certainly, his life is not all roses. In the last year alone Dr. Yau has been engaged in a very public fight with Beijing University, having accused it of corruption, and a New Yorker magazine article portrayed him as trying to horn in on credit for solving the Poincaré conjecture, a famous 100-year-old problem about the structure of space.

Everybody agrees that Dr. Yau is one of the great mathematicians of the age.

"Yau really is a genius," said Robert Greene, a mathematician at the University of California, Los Angeles. "The quantity and quality of the math he has done is overpowering."

But even his admirers say he has a political side. "As Shiing-Shen Chern's successor as emperor of Chinese mathematics," Deane Yang, a professor of mathematics at Polytechnic University in Brooklyn and an old family friend, wrote in a letter to The New Yorker, "Yau has an outsized ego and great ambition, and has done things that dismay his peers." But, Dr. Yang said, Dr. Yau has been a major force for good in mathematics and in China, a prodigious teacher who has trained 39 Ph.D.'s.

Richard Hamilton, a friend of Dr. Yau and a mathematician at Columbia, said Dr. Yau had built "an assembly of talent, not an empire of people, people attracted by his energy, his brilliant ideas and his unflagging support for first-rate mathematics, people whom Yau has brought together to work on the hardest problems."

A Barefoot Boy

That Shing-Tung Yau, born in 1949, had such potential was not always obvious. His family fled the mainland and the Communist takeover when he was a baby. As one of eight children of a college professor and a librarian, growing up poor without electricity or running water in a village outside Hong Kong, he was the leader of a street gang and often skipped school. But talks with his father instilled in him a love of literature and philosophy and, he learned when he started studying math, a taste for abstract thinking.

"In fact, I felt I can understand my father's conversations better after I learned geometry," he said at a talk in 2003.

When he was 14, his father died, leaving the family destitute and in debt. To assuage his pain, the young Mr. Yau retreated into his studies. To help out financially, he worked as a tutor.

At the Chinese University of Hong Kong, Mr. Yau emerged as a precocious mathematician, leaving after only three years, with no degree, for graduate school at the University of California, Berkeley.

Mr. Yau took six courses his first semester there, leaving scant time for lunch. By the end of his first year he had collaborated with a teacher to prove conjectures about the geometry of unusually warped spaces. He also came under the wing of Dr. Chern, then widely recognized as the greatest living Chinese-born mathematician, who told Mr. Yau he had already done enough work to write a doctoral thesis.

Dr. Yau was in Berkeley during the wildest years of the antiwar movement. He did not participate, but he was already political. He and his friends demonstrated at the Taiwan Consulate General in San Francisco to protest Japanese incursions on Chinese territory. “Maybe we envied our American colleagues and took after them,” Dr. Yau said.

In 1971, at age 22, Dr. Yau took his new Ph.D. to the Institute for Advanced Study, then to the State University of New York at Stony Brook and Stanford, where he arrived in 1973 in time for a conference on geometry and general relativity — Einstein’s theory that ascribes gravity to warped space-time geometry. At the conference, Dr. Yau had a brainstorm, realizing he could disprove a longstanding conjecture by the University of Pennsylvania professor Eugenio Calabi that the dimensions of space could be curled up like the loops in a carpet.

Dr. Yau set to work on a paper. But two months later he got a letter from Dr. Calabi and realized there was a gap in his reasoning. “I couldn’t sleep,” Dr. Yau recalled.

After agonizing for two weeks, he concluded that the opposite was true: the Calabi conjecture was right. His proof of that, published in 1976, made him a star.

His paper would also lay part of the foundation 10 years later for string theory, showing how most of the 10 dimensions of space-time required by the “theory of everything” could be rolled up out of sight in what are now called Calabi-Yau spaces.

Three years later, Dr. Yau proved another important result about Einstein’s theory of general relativity: any solution to Einstein’s equations must have positive energy. Otherwise, said Dr. Strominger, the Harvard physicist, space-time would be unstable — “you could have perpetual motion.”

The result is that Dr. Yau has lived a crossover life. As a pure mathematician, he is “a major figure, perhaps the major figure,” as Michael Anderson of SUNY Stony Brook called him, in building up differential geometry, the study of curves and surfaces.

Dr. Hamilton, the Columbia mathematician, said Dr. Yau liked to be in the center of things, unlike others who liked to retreat into a corner and think. “He seems to thrive on being bombarded with all this information,” he said.

He is also an honorary physicist, using “his muscular style,” in the words of Brian Greene, a Columbia string theorist who worked with Dr. Yau as a postdoctoral researcher at Harvard, to smash equations and get the physics out of them. “He corners equations like a lion after its prey,” Dr. Greene said, “then he seals all the exits.”

Prizes and honors flowed Dr. Yau’s way after the Calabi triumph, including the Fields Medal, a MacArthur “genius” grant in 1985 and a National Medal of Science in 1997. He became a United States citizen in 1990. (He said he put away the money from the MacArthur grant for his two children’s college education.)

A Wandering Son Returns

Dr. Yau married Yu Yun, an applied physicist from Taiwan, in 1976. At one point, when his family had preceded him on a move to San Diego, an institute colleague, Demetrios Christodoulou, noticed that Dr. Yau would pick up the phone late every night and start singing into it in Chinese.

“Yau is full of surprises, I thought to myself, now he wants to become a great opera singer,” Dr. Christodoulou recalled in an e-mail message. “As I later found out, these songs were lullabies for his children.”

It was natural that as Dr. Yau’s star rose, his “mother country,” as he put it, sought to pull him into its orbit. When he made his first trip back to China, in 1979, Dr. Yau became one of several returning heroes. A century of unhappy encounters with the West had left China with a deep sense of scientific and technological inferiority.

Dr. Yau has devoted himself to building up Chinese mathematics and promoting basic research, arranging for Chinese students to come to the United States, donating money and books, and tapping rich friends to found mathematics institutes in Hong Kong, Beijing and Hangzhou. He even lived in Taiwan in the early 1990’s so his children would learn Chinese.

In his travels he became friendly with President Jiang Zemin, then the leader of the Communist Party, who impressed him as “a smart guy.” The impression was mutual. When Mr. Jiang recited the first line of a Chinese poem at a dinner honoring intellectuals, Dr. Yau showed off his learning by reciting back the entire poem.

In 2004, Dr. Yau was honored at the Great Hall of the People for his contributions to Chinese mathematics. In a speech he said that when he won the Fields Medal, “I held no passport of any country and should certainly be considered Chinese.”

That same year Dr. Chern died at 93. Dr. Strominger recalled a newspaper headline declaring that with Chern’s death, “the era of Yau” was about to begin.

It has not been a peaceful era.

For the last year Dr. Yau has carried on a campaign against Beijing University, accusing it of committing fraud by padding its faculty with big names from overseas and paying them lucrative salaries for a few months of work.

A survey in Science magazine showed that the number of such part-time professors in China had grown to 89 from 6 over the last six years, while the number of full-time professors had risen to 101 from 66. The arrangement allows Chinese universities to piggyback on the glory of work these people do in their other jobs. Dr. Yau said it also drains resources that should go to young researchers.

This summer, Beijing University redesignated some overseas scholars to part time from full time. All this has taken a toll. “Yau is not universally loved,” said Mr. Chan, the real estate developer. “He has paid a price.”

Dr. Yau agreed. “I am completely outspoken. And I do offend people,” he said, adding that his style was to be intensely critical, both of his students and of his colleagues’ ideas.

Confrontations in China go all the way to the top, because all the money comes from the government, Dr. Yau said. “The only reason I have the nerve to resist,” he said, “is I’m a Harvard professor. I don’t draw a penny from China.”

“If I didn’t have the Fields Medal,” he added, “I would be dead to them.”

A Messy Proof

Dr. Yau’s eagerness to help China can backfire, and that seems to have happened in the case of the Poincaré

conjecture.

The conjecture, first set forth by Henri Poincaré in 1905, may be the most famous problem in mathematics and forms part of the foundation for topology, which deals with shapes. It says essentially that anything without holes is equivalent to a sphere.

In 1982, Dr. Hamilton of Columbia devised a method, known as the Ricci flow, to investigate the shapes of spaces. Dr. Yau was enthusiastic that this method might finally crack the Poincaré conjecture. He began working with Dr. Hamilton and urging others to work on it, with little success.

Then, in 2003, a Russian mathematician, Grigory Perelman, sketched a way to jump a roadblock that had stymied Dr. Hamilton and to prove the hallowed theorem as well as a more general one proposed by the Cornell mathematician William Thurston. Dr. Perelman promptly disappeared, leaving his colleagues to connect the dots.

Among those who took up that challenge, at the urging of Dr. Yau, were Huai-Dong Cao of Lehigh University, a former student, and Xi-Ping Zhu of Zhongshan University. Last June, Dr. Yau announced that they had succeeded and that the first complete proof would appear in The Asian Journal of Mathematics, at which he is the chief editor.

In a speech later that month during the string theory conference, Dr. Yau said, “In Perelman’s work, many key ideas of the proofs are sketched or outlined, but complete details of the proofs are often missing,” adding that the Cao-Zhu paper had filled some of these in with new arguments.

This annoyed many mathematicians, who felt that Dr. Yau had slighted Dr. Perelman. Other teams who were finishing their own connect-the-dots proofs said they had found no gaps in Dr. Perelman’s work. “There was no mystery they suddenly resolved,” said John Morgan of Columbia, who was working with Gang Tian of Princeton on a proof.

In August, Dr. Perelman was awarded the Fields Medal at a meeting of the International Mathematical Union in Madrid, but he declined to accept it. A week later a drawing in The New Yorker showed Dr. Yau trying to grab the Fields Medal from the neck of Dr. Perelman.

On his Web site, doctoryau.com, Dr. Yau has posted a 12-page letter showing what he and his lawyer say are errors in the article. The New Yorker has said it stands by its reporting. “My name is damaged in China,” Dr. Yau said. “I have to fix my reputation in China in order to help younger students.”

He denied that he had ever said there were gaps in Dr. Perelman’s work. “I said it is not understood by all people,” he said. “That is why it takes three more years.” As a “leading geometer,” Dr. Yau said he had a duty to dig out the truth of the proof.

Dr. Hamilton said, “In any long new work, it’s hard to figure out what’s going on.” It was natural, he said, that Dr. Yau would want people who had experience in the esoteric field of Ricci flow to check the proof.

Asked if promoting the Cao-Zhu paper so loudly had been a mistake, Dr. Yau said that even a small contribution to such a great achievement as proving the Poincaré conjecture would live in the history of science.

In addition, he said he wanted to encourage Dr. Zhu, who he said had been neglected by the Chinese establishment. Dr. Yau acknowledged that he also felt a duty to help explain Dr. Hamilton's work.

In a twist, a flaw has been discovered in the Cao-Zhu paper. One of the arguments that the authors used to fill in Dr. Perelman's proof is identical to one posted on the Internet in June 2003 by Bruce Kleiner, of Yale, and John Lott, of the University of Michigan, who had been trying to explicate Dr. Perelman's work.

In an erratum to run in The Asian Journal of Mathematics, Dr. Cao and Dr. Zhu acknowledge the mistake, saying they had forgotten that they studied and incorporated that material into their notes three years ago.

In an e-mail message, Dr. Yau said the incident was "unfortunate" but reaffirmed his decision to expedite the paper's publication. "Even after the correction, the paper provides many important new details and clarifications of Hamilton and Perelman's proof of the Poincaré and Thurston conjectures."

Many mathematicians are dismayed that the Poincaré triumph has become mired in a fight about credit and personalities. "In spite of the rivalries," Dr. Hamilton said, "we are deeply dependent on each other's work. None of us is working in a vacuum."

About the Poincaré proof, he said, "I've never seen Yau say that Perelman hadn't done it." No one, he added, had been more responsible than Dr. Yau for creating the Ricci flow program that won Dr. Perelman his prize.

Dr. Morgan said he still regarded Dr. Yau as his friend. "He has done tremendous things for math," he said. "He's a great figure. He's Shakespearean, larger than life. His virtues are larger than life, and his vices are larger than life."

Dr. Yau said the Poincaré conjecture was bigger than any prize and beyond politics.

"I work on mathematics because of its great beauty," he said. "History will judge this work, not a committee."