Science

Pitt math professor took best shot at cannonball conjecture

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By David Templeton, Pittsburgh Post-Gazette

There's no argument: The most efficient way to stack cannonballs is in a pyramid.

Stacking them any other way might result in one dropping on your toes. And it would be a waste of space.

But for four centuries, mathematicians had been unable to prove famed astronomer and mathematician Johannes Kepler's 1611 conjecture that the pyramid is the best way to stack cannonballs.

Rebecca Droke, Post-Gazette
University of Pittsburgh mathematician Thomas Hales -- "The hard part is going from intuition to rigorous mathematics to prove it."
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That is, until July 2006 when University of Pittsburgh mathematician Thomas C. Hales, and his former graduate student, Samuel P. Ferguson, published their proof of one of mathematics' most famous puzzles -- the Kepler conjecture.

Dr. Ferguson is a mathematician with the National Security Agency. Dr. Hales, 48, is Pitt's Andrew Mellon Professor of Mathematics.

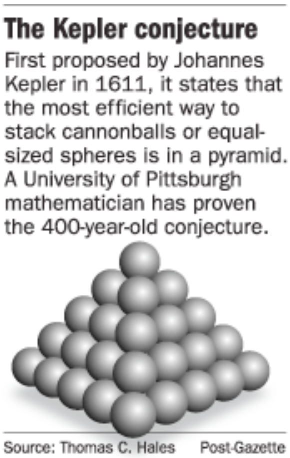
The cannonball proof has blasted Dr. Hales and Dr. Ferguson's names into the stratosphere of mathematical accomplishment.

Juan Manfredi, chairman of Pitt's Department of Mathematics, said Dr. Hales' name now "is in the history books.

"He will be remembered as the person who solved the Kepler conjecture -- the person who did the verification."

The proof is about 300 pages long -- not counting 40,000 lines of computer code and three billion bytes of data necessary to solve the puzzle that left mathematicians scratching their scalps for centuries.

Although Dr. Hales completed the proof in 1998, it took eight years for a panel of 12 mathematics referees to confirm it to 99-percent certitude and then have the proof published.



For their accomplishment, the American Mathematics Society presented Dr. Hales and Dr. Ferguson the first David P. Robbins Award and a $5,000 prize Jan. 6 during AMS's Joint Mathematics Meeting in New Orleans.

It's considered one of the major prizes for American mathematicians and will be awarded every three years. The AMS said their work "elegantly describes the main theoretical structure of the proof" and provides "an extensive road map" of their approach.

Kepler came up with conjecture after Sir Walter Raleigh asked mathematicians to determine the best way to stack cannonballs on ship decks. Intuition suggests the pyramid is the most efficient -- or densest -- way to stack cannonballs, but Kepler never proved the conjecture.

Centuries of mathematicians solved portions of it but never proved that cannonballs in a pyramid occupy less space than in any other configuration.

Twentieth century mathematicians figured out how many calculations were necessary to solve the conjecture, but the number was too enormous to undertake.

Dr. Hales started considering the conjecture in 1988 and had two things going for him -- computers and enjoyment of exhaustive mathematical problems to solve.

He and Dr. Ferguson studied 5,000 configurations of stacked spheres, which they reduced to 100 candidate configurations.

Then after years of effort, the "eureka moment" occurred in November 1994, when Dr. Hales figured out the ideal geometric forms that best described the relationship between spheres and the space they occupied.

Reducing the problem into creative geometry allowed a computer to do the calculations. But the computer had to run nonstop for three months to do many billions of calculations to complete the proof, he said.

"The hard part is going from intuition to rigorous mathematics to prove it," Dr. Hales said. It took four years to complete the proof even after the eureka moment.

Initially, he said, he was convinced the proof would not be as difficult as everyone claimed. "Once I figured out how hard it was, I was already hooked," he said, noting it became an obsession.

Even though he tends to work all day on mathematics and put everything else aside, he said completing the proof was akin to "crawling across the finish line of a marathon."

In 1998, Dr. Hales announced the proof was complete. Editors of Annals of Mathematics agreed to publish it, provided its panel of 12 referees could confirm it, which took many more years to complete.

Any remaining uncertainties can be proven only with advanced computer programs, and that defines Dr. Hales' next marathon challenge.

He's embarked upon a 20-year project to develop a computer program known as "FlysPecK" that could provide mathematical referees a means of confirming mathematical puzzles such as the Kepler conjecture. The capital letters in FlysPecK stand for Formal Proof of Kepler.

A Pitt professor for five years, Dr. Hales previously taught at the University of Michigan, the University of Chicago and Harvard.

Since proving the Kepler conjecture, he also solved the honeycomb conjecture by proving that the hexagon-shaped cells in honeycombs maximize area and minimize the amount of beeswax.

Jeffrey Lagarias, a University of Michigan mathematician, described Dr. Hales' Kepler proof as "an important accomplishment" in mathematics.

Dr. Manfredi said the accomplishment will put the Pitt math department on the map: "It's fantastic that he chose to come here."

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