University of Utah math professor Ken Golden drilling into sea ice during an expedition to Antarctica in 2007. Courtesy of Adam Gully.

Meet Ken Golden: Arctic adventurer and mathematician

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For most people, the words "math" and "adventure" don't go together. But for University of Utah mathematics professor Ken Golden, the two words might as well be synonyms.

Golden, 56, has been to Antarctica seven times and to the Arctic 10 times to study sea ice. After getting stranded on a ship in Antarctic sea ice, also known as the ice pack, for two weeks, surviving a ship engine fire and plenty of other hair-raising incidents, he's easily earned his nickname: the "Indiana Jones" of mathematics.

As for that burning ship — the main engine on the icebreaker Aurora Australis caught fire and the 54 scientists and passengers were just about to be ushered off the ship into lifeboats, according to a Science magazine (http://www.math.utah.edu/~golden/News_articles/Science_April_3_2009_Golden_Profile.pdf) profile on Golden. However, the fire was brought under control quickly, and the ship drifted through ice for two days without power before the crew could bring it back to life.

There's more to Golden's work than life-threatening conditions, though. The polar ice caps — which are essential to keeping the Earth from overheating — are disappearing at a faster rate than the world's best climate change models have predicted. By examining sea ice up close, Golden's research has helped improve predictions of how fast the ice that covers the Arctic and Southern Ocean is melting.

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Golden measures fluids' ability to pass through ice during a 2007 expedition to Antarctica. Courtesy of Jan Lieser.

Basically, Golden's "Rule of Fives" looks at how pockets of salty liquid water in the ice connect to form pathways. Under certain conditions, these small pockets link up to form channels for seawater to rise up to the surface of the sea ice, or trapped pools of water on top of the ice to drain down to the sea. The more pools of water — or melt ponds — that form on top of the sea ice, the more sunlight is absorbed. On a larger scale, as the ice disappears, more sunlight is absorbed by the world's oceans and they become warmer, which leads to even more sea ice melting.

Golden's research on sea ice also dips into other fields. He borrowed theories from military technology, such as stealth plane design, and applied them to sea ice dynamics. In return, he and his colleagues were able to adapt their sea ice research to develop a new method of monitoring osteoporosis, a disease that makes human bones fragile, Golden said in an interview with the National Science Foundation (http://www.nsf.gov/news/special_reports/science_nation/seaicemath.jsp).

The PHOENIX had a chance to chat with Golden about killer whales, Home Depot and the "wild west" of mathematics after his lecture on math and melting sea ice at Loyola on Sept. 29.

Loyola PHOENIX: How cool is it to be considered the "Indiana Jones" of math?

Ken Golden: It's certainly something that I was surprised by. I think a few friends of mine — just knowing my love of adventure — would call me that occasionally. The first time it appeared in print was when I was giving what was called the Porter Lecture in 2013. To publicize this lecture, they asked me to sign autographs on cards they made. Much to my surprise, I sat there and signed autographs for two hours. I told a reporter about this and she wrote something like "he's got this rock star status signing autographs." Then in the same article, she said something like "he's kind of like an Indiana Jones of mathematics."

To be honest, I think it's good for mathematics. It defies people's expectations and perceptions about what mathematics is, what it can be used for, what mathematicians do and how they spend their time. Most people don't think of mathematicians as going on these incredibly adventurous expeditions to the Antarctic and Arctic and ending up on burning ships or almost getting eaten by whales.

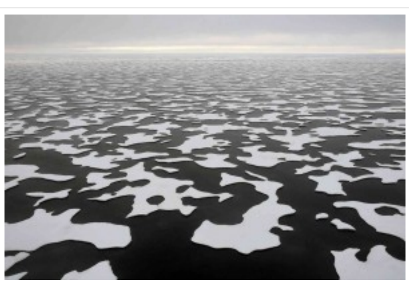
LP : Is it worth risking your life to do this research?

KG : Oh, absolutely. I mean — would I want to die in a situation like this? No, of course not. But I have been in some very sketchy situations — even the night that I discovered the "Rule of Fives." Earlier that night, I saw seawater percolating up and flooding the surface [of the ice] during a massive storm with 60 mph winds, snow and ice breaking apart. We needed to measure some ice thickness, so I had to get this measurement on extremely thin ice. This is not regular frozen pure water; this is fluid-laced ice, which makes it much weaker. So I stretched out, and [the crew] held my legs. If I fell in, I would have died because, in that water, you die within a minute or two just from the temperature. We've been in a lot of situations like that where you need to get something done or you're dealing with all these animals around that you're just food as far as they're concerned.

LP : You first got interested in sea ice during high school. Did you ever expect your interest to lead you so far?

KG : Of course not. I always knew I was going to become a math major because math is the language of the sciences, but I actually wanted to be a test pilot and fly jets. Because of my eyes, I had to choose a different path.

For a short period of time, that dictated what I did in high school, like study sea ice at NASA. I went to Dartmouth partly for a great undergraduate education, but also the



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U.S. Army Cold Regions Research and Engineering Laboratory was one mile away.

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Melt ponds, or pools of water on top of sea ice, occur naturally during the summer months in the polar regions. Courtesy of Karen Fray.

When I got to Dartmouth, though, I fell in love with physics in addition to mathematics and the interplay between the two of them. I wanted to become a mathematical physicist. Even when I was going to Antarctica my senior year, I was already applying to math grad schools. The plan was to become a math professor. I certainly never had the intention of getting back into sea ice.

I spent about 10 years away [finishing my PhD and teaching at Princeton]. Then I moved to Utah. I got a call from my college mentor — the guy who first took me to Antarctica — and he said there was a big research project getting started to develop the next generation of sea ice electromagnetics. That got me back into sea ice.

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National Science Foundation mathematics postdoctoral fellow Joyce Lin and professor of electrical and computer engineering Cindy Furse setting up an ice corer. Courtesy of Ken Golden.

LP : Most people have not been to Antarctica or the Arctic. Seeing it was one thing, experiencing is another. Can you describe the feeling you get when you're in these places?

KG : It's really like a different world. Part of it is the adventure of getting down there, especially by icebreaker. You sail down for four to six days through the Southern Ocean, and you're getting colder and colder. All of a sudden, you hear ice scraping the side. It's that adventure of going on a big ship and going to a place where most people don't — all the big storms and the big waves. It's the whole act of just getting down there that makes it seem so remote. You can go for three or four days when the weather is just horrible so you hardly see anything. Then all of a sudden, there are icebergs, penguins, killer whales. You can't believe what you're seeing. It's just incredible.

At this stage of my life, I've done it so many times that it's one of my homes, one of the places I feel really comfortable. The first couple of times down, though, especially being on a burning ship, that was pretty wild.

LP : For most people, it would be very unnerving.

KG : Fortunately, it doesn't affect me that way. But I've seen some people get a little freaked out. When you start to think about where you really are, if something goes wrong, you're about 2,000 miles from anybody. Especially when you're in the ice pack, no one is coming to get you.

That's why there are extremely stringent medical requirements. My doctor actually told me that the only time he's ever seen anybody go through such rigorous exams as well as procedures was a CIA field agent going to Afghanistan.

The ship costs $50,000 a day to run, and people's careers are hanging in the balance. They don't want to turn the ship around because somebody had a wisdom tooth issue. I had to have all four of my wisdom teeth taken out. Otherwise, they won't let you go.

LP: During your lecture, you said, "I do Home Depot science." Can you expand on that?

KG: Some of the things we do, they're not incredibly delicate, detailed experiments. They're more like, "Hey let's take this big PVC pipe, stick it in the ground and wrap it with Styrofoam that we got from a dumpster." I spend a lot of time at Home Depot before I go on these expeditions. We use millions of Ziploc bags. We use all kinds of saws and stuff to build little platforms to do our experiments with. It's so hands-on. Yes, we do have a $30,000 network analyzer as well. That's a very fancy, expensive instrument that you could not pick up at Home Depot. So, it's a combination of things.

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LP: We hear a lot about your fieldwork. Why is it important to work both in and out of the office?

KG: Fieldwork is very important for doing relevant mathematics, but it goes both ways. The mathematics helps me design and ask the kinds of questions that not everybody asks. And also there's just the experiences I have in the field that then leads to new mathematics. By going down [to Antarctica], and actually experiencing the phenomena, it redirected the questions I was asking.

LP : If you could go back in time and give your undergraduate self some advice, what would you say?

KG : Trust your gut instincts. It's been one of those themes of my life. If I trust my gut instincts, it usually plays out in the way that I planned originally. If I get waylaid, sidetracked or don't follow it through, then it doesn't happen. I made a decision around sixth grade, I think I was 10 years old, that I was going to be a math major. By going on this roundabout way, and picking up all these incredibly powerful tools, I got back to sea ice by being a mathematical physicist.

LP : You deal so much with climate change, do you consider yourself a climate change activist or a climate scientist?

KG : I'm not a climate change activist. But I guess I am [a climate scientist] because I've become so intimately related with climate change.

In 2009, I was asked to be the national chair for Math Awareness Month and it was about mathematics and climate. It was at that point that I figured I was being put in this leadership role as to how mathematics is being used to address climate science. I should at least know what's in the public sphere about climate change. So I started investigating things and started to develop my own opinions about climate change. I realized I had to step out of my theorem-proven mathematician mindset.

LP : Your research has been applied to medical advances along with weaponry. How do you want your research to be used?

KG : I do want it to be used to help our understanding of the climate system and to improve our projections of climate change and the role of sea ice in it. My background is in composite materials, and that was one of the reasons why I went into composite materials; it's so pervasive. From that perspective, I would like my research used in other sorts of high-tech applications and medical applications. After all, I am an adjunct professor of bioengineering, not that I've ever had training in biology or engineering! But again, that demonstrates the power of mathematics and physics. With that background you can do so many things

LP : So what exactly is a composite material...?

KG : Two or more different materials that create a new material. Like human bone — human bone is a hard mineral with soft tissue inside. For me, sea ice is one of the most fascinating composites. It's really a four-phase composite of pure ice, liquid brine, solid salts and air. There are these four different substances, and, in the case of sea ice, it's a solid, fluid and gas.

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Two emperor penguins waddle along the Antarctic ice. Courtesy of Ken Golden.

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During the winter in Antarctica, the sun doesn't shine for several weeks starting in mid-June. Courtesy of Ken Golden.

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A shot of the icebreaker Aurora Australis moving through sea ice as seen from a helicopter. Courtesy of Alison Kohout.

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