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In Antarctica, searching for neutrinos and scientific inspiration

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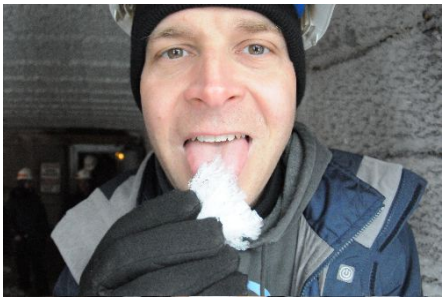


What would compel you to travel to the ends of the earth?

For **Casey O'Hara**, a high school physics teacher in California, it was the chance to step out of the classroom and get his hands dirty helping researchers conduct cutting-edge scientific experiments.

Traveling to the South Pole on the world's last continent, Antarctica, O'Hara endured temperatures of 35 degrees below zero, altitudes upward of 9,000 ft. and days without sunsets to work on **IceCube**, the world's largest neutrino telescope, made entirely out of ice.

I spoke with O'Hara on his final day in Antarctica to discuss the science behind neutrinos and his secrets to surviving in one of the coldest locations on the planet.

SmartPlanet: What are you researching at the South Pole?

Casey O'Hara: It's actually pretty amazing here. I'm working on one of the research projects being done down here, all going on simultaneously. IceCube is the largest of all of those. It's an observatory where we're looking for neutrinos.

if you were to take a telescope and aim it up at the sky, you're going to see the universe in a particular way. With other technology — infrared, ultraviolet, some of those things — the universe looks a lot different. X-rays versus microwaves, and so forth. Each way looks a little different.

We're looking for "extrasolar" neutrinos, or those that come from places other than the sun. We're not interested in solar neutrinos — plenty of research has been done on those. We're looking for sources of higher-energy events — the formation of black holes and galactic collisions and supernovas and things that are much larger than the sun. Those

[neutrinos] will have much higher energies. The telescope is able to differentiate between the two.

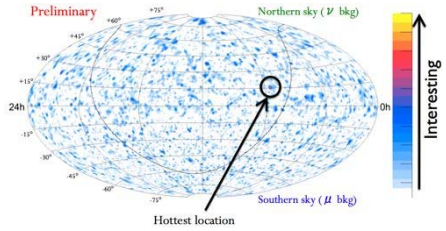
SmartPlanet: What does Antarctica have to do with neutrino research? Why there?

COH: We're sitting on top of two miles of ice. Neutrinos are a fundamental particle of the universe — think of them like an electron with no electric charge. They're not affected by electromagnetic force, which is why they're so cool — they pass through pretty much everything. They're not affected by atoms.

Every second that goes by, there are on average 50 to 100 trillion neutrinos pass through a person each second. If you live to 100, there's a chance that one neutrino could react with your body.

On extremely rare occasions, a neutrino makes a direct hit on a proton or neutron and interacts. One of the quarks in the proton flips and turns it into a neutron, or vice versa. To maintain balance, a new particle is emitted, called a muon, going the same direction and speed as the original neutrino.

The muon is something we can detect pretty easily. If it's a clear material — such as ice — the muon can go through it faster than light itself. It bleeds off some of its energy in the form of radiation. It's like the wake of a speedboat, or a shockwave from a plane moving faster than the speed of sound. If you have a light sensor, you can detect it.



With IceCube, the neutrinos are hitting into atoms, creating muons, which bleed off light when they hit the ice. We put detectors into the ice. The bigger the area, the more chances you have to catch a neutrino in action.

Instead of a swimming pool-size [sensor array], we have one kilometer on each side. It's enormous — the biggest telescope ever made. The biggest and most expensive project ever attempted down here in Antarctica.

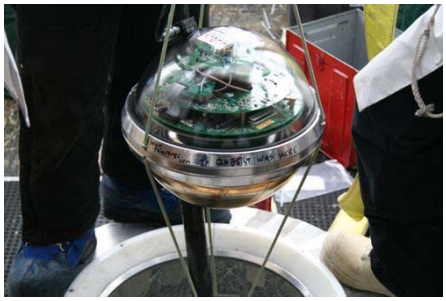
We drill 2.5 kilometers (approx. 1.6 mi.) down into ice — the sensors are located in the very bottom 1 kilometer — in a hexagon-shaped array. This year, they'll have 79 holes in the ground with 60 sensors apiece — that's 4,740 sensors. With all of that, [scientists] can look at all this data in a number of different ways.

SmartPlanet: What is the value of the neutrino? Why expend all this effort?

COH: With neutrinos, it's a little abstract. We can barely detect them, much less use them in any useful way. It's just the process of discovery. There is no forseeable use for neutrinos aside from the fact that they bring us information about the universe that we

wouldn't get from other sources. We might learn more things about black holes and supernovas.

Next year, the entire design of the array will be in the ice. Even up until now, they've been collecting data — ever since they put sensors into the ice. But that data's not very conclusive. It's just a few hundred neutrino interactions. As of now, there's not enough data to differentiate the signal from the noise.



Once it's complete, they'll be able to capture data with higher resolution. This observatory is designed to be taking data for at least 20 years. Eventually, they'll be able to filter out the random background noise and figure out what spots in the sky we're getting neutrinos from.

[The scientists] have learned a lot about the way neutrinos work. They've also learned a bunch of other things just building it. Like drilling into a huge slab of moving ice — they've discovered layers of ash and dust inside the ice. Glaciologists have taken that data and looked at how the ice is moving over time and where that dust corresponds to an event in history.

SmartPlanet: What is it like to work in Antarctica?

COH: It's really cold here, even in the summertime. The average temperatures have been minus 25 degrees Celsius (or minus 13 degrees Fahrenheit). A month ago, it was minus 40 degrees Celsius (or minus 40 degrees Fahrenheit). In the winter, it can be minus 100 Fahrenheit.

What I've been surprised by, when it's sunny and not windy, minus 25 Celsius isn't that bad. The sun basically never changes its altitude. It just spins around in the sky. You get

24 hours of sunlight. That's been sort of a subtle, creeping sort of effect. It messes with your sleep cycles.

It's weird, but at the same time, it's kinda cool.

Our altitude is officially 9,301 feet. The atmosphere is also a little thinner, so it seems like you're over 10,000 feet. Breathing can be hard sometimes.

SmartPlanet: It's your last day at South Pole Station. What will you do once you return to the Bay Area? What will you bring back to the classroom?

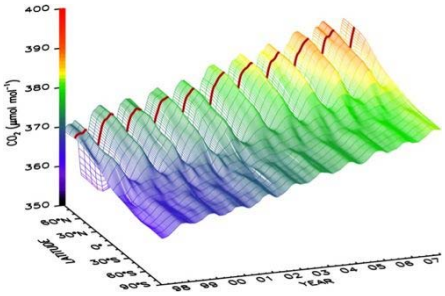
COH: I'm going to sleep for a long time. (laughs) The 24 hours of sunlight and altitude…you look around the station and everybody's got big, dark circles under their eyes. I return to class on January 6 — it'll be great to return to the classroom and tell them about my experience.

Neutrinos are not a part of the California state physics standards, but it'll keep the students excited.

Students in general enjoy science if it's taught well and they're experiencing it, rather than just reading it out of a textbook. Everybody's born with an innate curiosity. Everybody's a scientist at heart. They want to figure out how something works.

SmartPlanet: The Copenhagen Climate Change conference and Climategate controversy occurred while you were in Antarctica. What climate change science are researchers studying down there?

COH: There are a lot of different projects going on down here. NOAA runs an observatory down here called the Atmospheric Research Observatory, and one of the things they're looking at besides the ice cores is the air. There's some of the cleanest air in the world down here, with no significant population.



They take samples every day, run it through testing machinery, and compare it to data taken at other latitudes across the world. They can look at carbon dioxide levels over time. There's definitely climate change research going on down here. They've seen carbon dioxide levels
rising, chlorofluorocarbons destroying the ozone layer. They think [the ozone layer] at its bottom right now and they're expecting it to heal up soon. The residual stuff up there is starting to work its way out of the system.

SmartPlanet: What's it like to work on the seventh continent, a neutral land reserved only for scientific research? Is it effective in that role?

COH: It's actually the 50-year anniversary of the Antarctic Treaty this year. No military use — purely scientific research.

One of the big benefits of that is that it fosters international cooperation. Here at the South Pole it's officially a U.S. station, but we have scientists coming from eight or 10 different countries on just one project. Science is fairly universal. To be a scientist, you have to understand the nature of evidence and how you gather it. Projects will have one principal investigator and partnering institutions follow that lead. That's the main way

it's coordinated. Most of the people down here are able to speak English, whether by accident or design.

It's actually been really interesting — even just the people doing the drilling or deployment or construction, everybody talks to each other about these scientific ideas. You have a much more scientifically literate population down here. You can talk to the people who drive the shuttles about neutrinos and they can talk to you right back about it. I was working with a German science professor and it was fascinating to talk to him and learn more about neutrinos.

SmartPlanet: What have you learned?

COH: One of the key takeaway points was the idea of getting science teachers involved in some form of actual research. It doesn't necessarily matter what that research is — just to see how science is done in the real world. To experience it firsthand and understand what's really going on out there and apply it to any kind of discovery is exciting. It doesn't have to be at the South Pole.

As a science teacher, hopefully I can use it get my kids excited about what science is really like.

The Knowles Science Teaching Foundation supports new science teachers in their first five years of teaching. An investigator from IceCube came and gave a keynote speech at a KSTF event and asked if anyone was interested in going to Antarctica. A few of us were. It's been a fantastic experience.

Interested in more? Read Casey's PolarTrec blog, where he answers questions from young science students and offers daily entries about his experiences on the world's coldest continent.