

Catching Some Rays

A simple but groundbreaking observatory in central Mexico is shedding new light on the workings of cosmic and gamma rays in Earth's atmosphere. Formally opened a year ago, the High-Altitude Water Cherenkov Gamma-Ray Observatory will be used by scientists to gather information on high-energy particle acceleration for 10 years. The observatory is perched on the side of the Sierra Negra volcano, almost 14,000 feet above sea level. Segev BenZvi, an assistant professor of physics, helped to create the observatory and is part of the team now carrying out research there.

Air Showers

When high-energy gamma rays and cosmic rays interact high in the atmosphere, they create a particle cascade that peaks as it falls to Earth and wanes before it reaches the ground. The cascade, which moves at the speed of light, looks like a pancake that grows wider and wider as it nears ground level.

Gamma Rays

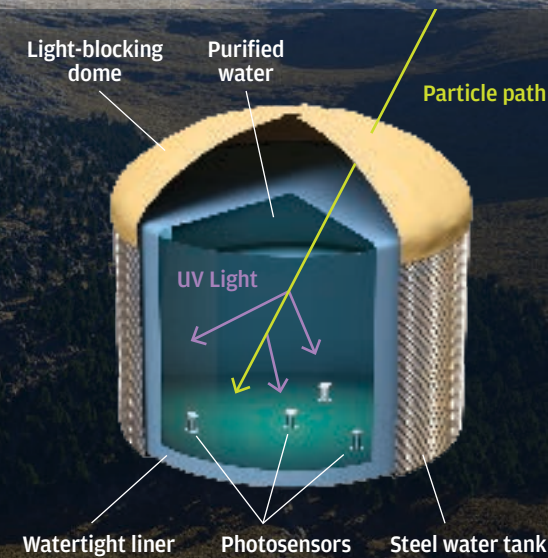
Using the observatory, scientists can distinguish between air showers created by gamma rays and cosmic rays. At ground level, most of the signal from the particle cascade is centered around the direction of the initial gamma ray. But cosmic ray showers are much less orderly, breaking apart as they descend.

Water Cherenkov Tank Array

Giant water tanks outfitted with photosensors sample air-shower particles by recording the light produced when the particles move through the water.

High-Altitude Water Cherenkov Gamma-Ray Observatory

*Citlaltépetl
(Pico de Orizaba)
18,491 feet*



Cherenkov Effect

When particles reach the ground, they move through the water tanks, producing ultraviolet light, in a process known as the Cherenkov effect. Photosensors in each tank record the light. By studying when the sensors are triggered, researchers can deduce information about the air shower of particles.



Tanks and Pancakes

Physicist Segev BenZvi and scientists at an ambitious observatory use simple tools to probe the universe.

Three hundred giant tanks, each holding more than 50,000 gallons of purified water, perch on the side of the Sierra Negra volcano in central Mexico, standing 13,500 feet above sea level. Four photosensors lie at the bottom of each tank.

The array of tanks is part of the High-Altitude Water Cherenkov Gamma-Ray Observatory, or HAWC, a joint project of Mexico and the United States. While the technology is comparatively simple, the project is ambitious: observing gamma and cosmic rays, and contributing to the search for dark matter.

Segev BenZvi, an assistant professor of physics, and fellow

water tank in the lab to measure for muons—heavy, unstable versions of electrons that are the ground-level remnants of particle cascades.

But the project is innovative in three ways: its high-altitude location brings better sensitivity to the particles, which get absorbed by the atmosphere as they descend; its “optically isolated, densely packed” tanks; and the algorithms that let the scientists make use of the data they assemble.

Construction of the observatory began in 2011 at a site in the Parque Nacional Pico de Orizaba, a national park and home to the dormant volcano Pico de

BenZvi and colleagues on the project are studying extremely high-energy particle acceleration, from supernova remnants, black holes, neutron stars, and pulsars—“objects with very, very large amounts of energy,” he says.

scientists are looking for very energetic gamma rays and cosmic rays that enter Earth's atmosphere. When the high-energy rays interact, they create a “particle cascade”—a shower of high-energy particles—that falls to Earth.

BenZvi and colleagues on the project are studying extremely high-energy particle acceleration, from supernova remnants, black holes, neutron stars, and pulsars—“objects with very, very large amounts of energy, some of which is being dumped into accelerating charged particles out in space,” he says. When they interact, they produce gamma rays and cosmic rays.

HAWC is a “scaled-up” version of a classic physics student experiment, he says, that uses a

Orizaba, Mexico's highest peak. HAWC was formally opened last spring. When the experiments are complete, in about 10 years, the scientists will restore the area to as close to its original condition as they can. The park is a “cloud forest,” with one of the highest tree lines in the world. An environmentally sensitive site, the forest affects cloud formation and rainfall in areas south and west of the park. No trees were removed in creating the observatory.

The high-altitude location poses minor challenges for researchers, like shortness of breath, says BenZvi. “And shortness of temper, believe it or not,” he says. “You just get really irritated. Your thinking isn't very clear. I find that I get bad at doing

basic arithmetic in my head when I'm up there."

The enormous tanks—23 feet wide and more than 16 feet high—are the same kind of tanks used by Midwestern farmers to irrigate their fields. A military contractor who manufactures "light-tight" tents for soldiers in hostile territory makes the tanks' hemispherical domes.

Local workers assembled the tank array, and then made 4,000 trips by truck up and down the mountain to haul the water to fill them—a volume of 55 million liters, or the equivalent of a soda can's worth of water for each person living in Mexico.

The tanks sample the air shower particles at ground level. There are about 100 million particles in a cascade at its peak. The number of particles decreases as the cascade descends.

"It's like a pancake of high-energy particles that moves toward the ground," BenZvi says. When the particles hit the ground, they move through the tanks—and when high-energy particles move through water, they produce ultraviolet light, known as the Cherenkov effect. The photosensors in the tank record the ultraviolet light. And from the pattern of times that the sensors in each tank are triggered, scientists can reconstruct the direction of the particle pancake.

The data they collect may also shed some light, as it were, on dark matter.

"There is very strong evidence, from all kinds of measurements in astrophysics, that there is something called dark matter," BenZvi says. "But it's not clear what it is. We think it's a fundamental particle or particles."

But scientists don't know how massive it is or what its interactions are. "So it's entirely possible that some of the gamma rays and cosmic rays that we see are actually not produced by neutron stars and supernovae and things like that—they're actually produced when clumps of dark matter interact and decay. That's the idea," he says.

When anomalies are found in astrophysical data, scientists consider whether the source of the anomaly is a mistake in their model or the influence of dark matter.

"And that's kind of the name of the game," says BenZvi. "It's a tough game, as you can imagine. It's sort of like the joke about 'unknown unknowns'—you don't know what you're not modeling."

Telescopes offer another way to measure gamma rays. But they have a narrow field of view, taking in only a few degrees of the sky at a time. HAWC records information from two-thirds of the sky every 24 hours.

"Over the course of one day, we can see essentially the entire northern hemisphere," says BenZvi, noting that the methods are complementary. "We've made the bet on more coverage, less sensitivity; they make the bet on more sensitivity, less coverage. If you have both types of instruments running, you can look for unexpected stuff with HAWC—we communicate with those guys through back channels: 'Hey, we see something interesting. Point your telescope there.' And that's how a lot of the field works."

Scientists are now processing their first year's worth of data from HAWC, which they began to make public this spring. And they are expanding the array with some additional tanks—just a few, which will bring with them a four-fold increase in sensitivity.

And there is talk of creating a second observatory, possibly in Chile. The southern hemisphere provides the best vantage point for observing the center of the galaxy—and it's "a very strong candidate for observing dark matter, because we believe there's a super-massive black hole in the center of the galaxy, and so there should be a gravitational well there where dark matter is concentrated," says BenZvi.

"If we have a HAWC in the southern hemisphere, literally the center of the galaxy will be right overhead," he says.

—Kathleen McGarvey



CONVENING SCOTS: Scholars are gathering at Robbins Library to discuss texts written in Older Scots, a descendant of northern Old English that was used in medieval and early modern Scotland.

Brushing Up on Older Scots

Scholars discuss the literature of medieval and early modern Scotland.

Feeling like a *cummerworld*, or even a *dowbart*, because your Older Scots vocabulary is a bit rusty? Fear not: you needn't be looking *glaiokit* for long.

In May, the University is hosting the Rochester-St Andrews Conference on Older Scots Literature and Culture. The gathering draws specialists from the United States, Canada, and Europe to share papers on 14th- to 16th-century literature in Older Scots, the descendant of Old English that was used in medieval and early modern Scotland.

Rhiannon Purdie of the University of St Andrews in Fife, Scotland, who is visiting the University's Robbins Library as a Fulbright Scottish Studies Scholar, and Thomas Hahn, professor of English, organized the event. Papers examine early literary and political texts, historiography, and language and ethnicity, among other subjects.

The Robbins Library is home to the Middle English Texts Series, sponsored by the Consortium for the Teaching of the Middle Ages. Among the nearly 100 volumes published, the series has made

Meet a Few Terms from Older Scots . . .

cummerworld: n. useless person (i.e., "encumber-world")

dowbart: n. dimwit

dreich: adj. tedious, dreary; (of weather) grey and miserable. Still common in modern usage.

glaiok: n. fool; **glaiokit:** adj. idiotic

liddir: adj. slow, sluggish, indecisive

maggil, maggle: v. to spoil

maggilit: adj. mangled, ruined

nipcaik: n. miser

quean: n. wench

skaldit skaitbird: n. scabby scavenger

skamelar: n. parasite

slawsy: n. fellow, guy

walidrag: n. wastrel

available, in digital and hard copy, a number of Older Scots writings and more are in production, helping to make Older Scots literature more accessible to teachers and students around the world.

More information about the conference is on its website: Olderscots.com.

—Kathleen McGarvey

Accessing a New Point of View

Scholar Beth Jörgensen turns the lens of disability studies on Latin American culture.

When Beth Jörgensen, a professor of Spanish, prepared in 2009 to teach a course about coming-of-age stories in Latin America, she reversed the common academic order of things.

"Very often, our research contributes much to our teaching," she says. "My engagement with disability studies over the last seven years actually came directly out of teaching."

Jörgensen decided to include in the course the book *Gaby Brimmer: An Autobiography in Three Voices*. The collaborative memoir tells the life story of Gabriela Brimmer, who was born to Austrian-Jewish immigrant parents in Mexico City in 1947. Brimmer learned to communicate by manipulating an alphabet board with the big toe of her left foot, the only part of her body that cerebral palsy allowed her to control.

To teach the book, Jörgensen immersed herself in disability studies, a field of cultural criticism that has emerged gradually over the past three decades. Now she's the coeditor of a new book, *Libre Acceso: Latin American Literature and Film through Disability Studies* (State University of New York Press, 2016). With Susan Antebi of the University of Toronto, Jörgensen assembled the critical essays to turn the lens of disability studies on Latin American literature, film, and culture.

Disability studies may not yet have the wide recognition that women's studies or African-American studies do, but their origins are similar.

"There's an activist piece to it," says Jörgensen. "Women's studies came out of the women's rights movement; African-American studies came out of the civil rights movement, in many ways. And disability studies has its roots in the disability rights activism of the last 30 years."

The approach emphasizes reading literature, viewing film, and theorizing about culture to



"All of the essays make a case for the importance of inclusion, of how much we miss out on the richness of human diversity if we are not inclusive of people with disabilities."—Beth Jörgensen

see how societies construct and view disability.

"It has become quite an important way of looking at literature, film, and art, especially in Britain and North America—Mexico, much less so," she says. And in Latin American studies, its potential has been little explored.

The best-known literary work discussed in *Libre Acceso* is Gabriel Garcia Márquez's *One Hundred Years of Solitude*. In his essay, critic Juan Manuel Espinosa suggests that the novel can be read as an exploration of how a

person with Asperger's syndrome experiences the world.

Jörgensen calls her introduction to the field "eye-opening." She began to "see things in literature that I hadn't even noticed before, because I didn't have the intellectual tools to notice them."

But once readers begin to notice the trope of disability, they realize it's omnipresent. The figure of a character with a disability is pervasive in world literature, she says, from at least the time of Oedipus. But critics haven't until recently begun to

consider what can be illuminated by considering the category "disability" carefully. Often, it's a kind of plot device, she says, a "narrative prosthetic" that sets events or conflicts in motion, or a metaphor for social ills, or a mechanism for the moral growth of a non-disabled character.

The field has reshaped Jörgensen's own understanding of disability and the concept of accommodation. Buildings are heated in the winter as an accommodation of our physical need for warmth, she points out.

"Society accommodates all of us," she says. "Is it really a special accommodation, then, to put in curb cuts for people with disabilities?"

Common themes emerge in the essays, such as the "intersectionality" of identity that occurs when one is not only disabled, but also poor and a minority member of society. "You can't just isolate the disability as if nothing else were also determining that person's destiny," Jörgensen says.

"All of the essays," she adds, "make a case for the importance of inclusion, of how much we miss out on the richness of human diversity if we are not inclusive of people with disabilities."

And now Jörgensen's research on disability studies is informing her teaching. Last fall, she taught a new course, *Disability Studies: Rethinking Difference and Diversity*, in which she introduced students to scholarship that treats disability identities both as physical realities and as social and cultural constructions. The course also explores the literary representations of physical, intellectual, and psychosocial disability in works from a variety of national traditions.

"Teaching a single book, and trying to bone up on what I needed to know to do a good job of teaching that book, opened a new field for me," she says.

—Bob Marcotte, with Kathleen McGarvey