

Steven Weinberg has been among the most outspoken critics of campus carry in Texas. He says he will ban guns from his classroom. It's unclear if such a move could be legally challenged, but campus administrators are concerned that the state might retaliate by tightening the financial reins on the university.

And the dildos? They were the brainchild of UT Austin alumnus Jessica Jin. "A lot of the debate is ideological," she

says. "The spirit of higher education is the opposite of gun culture. It's sad that people have come to accept campus carry." When she heard about campus carry, her first thought was "what dildos" the people were who wanted guns on campus. That thought led her to check the legality of carrying a dildo on campus. It's considered obscene and is a misdemeanor in Texas, she says.

Last fall Jin created a Facebook event

to organize a protest that more than 10 000 people have signed on to. Now she is working out how to distribute thousands of silicone dildos donated by manufacturers. The plan is for students and others to dangle the sex toys from their backpacks come 24 August, the first day of classes. "We are fighting absurdity with absurdity. If you are squirming at a dildo, you most certainly should squirm at a gun," she says.

Toni Feder

Disputed dark-matter result gets put to the test

Despite nearly two decades of scrutiny, nobody has yet explained away—or confirmed—DAMA's claim of detecting the elusive matter.

If the leading hypothesis is right, dark matter consists of particles that interact only through gravity and the weak force. Billions of those weakly interacting massive particles could be passing through our bodies every second.

Unfortunately for physicists hunting the elusive stuff, which makes up about a quarter of the universe, the particles also seem to pass unimpeded through detectors designed to find them. Dozens of multimillion-dollar direct-detection experiments across the globe have either come up empty or found feeble hints that couldn't be definitively distinguished from background noise.

There is one possible outlier: an experiment named DAMA. For nearly two decades the experiment's two dozen researchers from Italy and China have claimed that their sodium iodide detectors, buried under about 1500 m of rock in Gran Sasso mountain in Italy, have spotted a signature tantalizingly consistent with dark matter. They point to a signal that peaks in the summer and wanes in the winter, a cycle that's expected as Earth's relative speed through the galaxy's dark-matter halo changes over the course of a year. The current iteration of the experiment, called DAMA/LIBRA, pegs the statistical significance of the annual modulation at 9.3 standard deviations.



DAMA/LIBRA COLLABORATION

TECHNICIANS WITH THE DAMA EXPERIMENT examine the observatory's copper-shielded sodium iodide detectors during a 2010 upgrade. The DAMA collaboration says that since the late 1990s it has measured a signal consistent with dark matter.

Rather than celebrate what likely would be a Nobel-worthy discovery, many physicists have treated the DAMA results with skepticism. For one thing, experiments using other elements for their detectors, such as xenon, silicon, or germanium, have failed to find particles resembling dark matter.

Some experimenters claim to have all but ruled out the possibility of particles with the range of energies suggested by the DAMA results. Compounding the concerns is a perception that DAMA researchers are too secretive about their equipment and data, which makes evaluating the results difficult and replicating the experiment even tougher.

Now multiple experiments that use the same detector medium are finally

getting ready to put DAMA to the test. Within the next few months, two collaborations working in Europe and Asia will start investigating whether their buried sodium iodide crystals exhibit the same annual cycle of detections as DAMA's.

Then, in another year or two, the Sodium Iodide with Active Background Rejection experiment, known as SABRE, should begin hunting dark matter from both sides of the equator with detectors even sharper than the ones currently tucked beneath Gran Sasso. "I don't think there's any doubt that DAMA sees an annual modulation," says Frank Calaprice, a Princeton University particle physicist who heads SABRE. "But is it dark matter? I want to focus on doing



THE SODIUM IODIDE DETECTORS FOR THE DM-ICE EXPERIMENT are lowered into the Antarctic ice in 2010. DM-Ice will now use an improved set of detectors at a South Korean underground laboratory.

a really good measurement to find out.”

Ultrafast particles passing through sodium iodide crystals excite the lattice’s atoms, which emit flashes of light when they return to the ground state. An interacting dark-matter particle, even one with very little energy, should trigger a detectable signal, provided its interaction cross section is not vanishingly small. But a stray cosmic ray, neutron, or radioactive impurity in the crystal can also elicit a flash. As a result, DAMA went to great lengths to obtain impeccably pure crystals and to house them in a location shielded from the noisy outside world.

The DAMA team has spent on the order of \$1 million to procure a few hundred kilograms of sodium iodide crystals from Saint-Gobain Crystals in Saint-Pierre-lès-Nemours, France, according to Vladimir Ouspenski, the multinational company’s crystal senior scientist. (Italy’s National Institute for Nuclear Physics has provided much of the funding.) Sodium iodide crystals typically sell for a couple of dollars per cubic centimeter, Ouspenski says. But because of their extreme purity, DAMA’s crystals are at least 10 times as expensive.

Saint-Gobain limited potassium-40 to concentrations of about 20 ppb, more than two orders of magnitude below the concentration in typical sodium iodide crystals. Potassium-40 is a particularly worrisome contaminant because it’s radioactive and can stealthily take the place of sodium atoms in the lattice. When rogue potassium atoms decay,

they emit flashes of light that could easily be mistaken for a signature of dark matter.

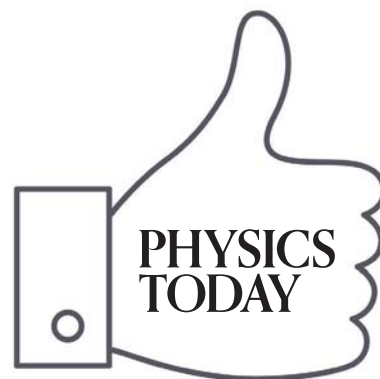
Researchers at DAMA exploit the Gran Sasso National Laboratory’s position under the mountain to isolate 250 kg of ultrasensitive crystals from subatomic and electromagnetic pollution. The copper that houses the detectors was taken from a shipwreck; the French battleship, submerged in the Mediterranean Sea since the 19th century, never got contaminated by the cobalt-60 that rained down on the globe from atomic-bomb explosions. Additional protective shields include lead to block gamma radiation and cadmium to ward off neutrons.

A stubbornly persistent signal

In 1997, at an international workshop on astroparticle and underground physics, DAMA spokesperson Rita Bernabei and her team presented their first evidence of a signature of dark matter: a small but distinct seasonal excess of flashes with energies between 2 keV and 6 keV. The experiment couldn’t determine whether those flashes were triggered by dark matter or other particles. But the signal is consistent with theoretical predictions. In the Northern Hemisphere summer, Earth is traveling through the galaxy in the same direction as the Sun, and so it plunges faster through the stationary halo of dark matter than it does in northern winter.

By 2000, when DAMA had obtained even stronger evidence, the *New York Times* picked up on the excitement—

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but also quoted scientists noting that variations in temperature or natural radioactivity could mimic the annual cycle.

Several scientists, including ones involved in the follow-up experiments about to start up, complain that DAMA researchers haven't provided enough information to allow others to fully evaluate the claimed detection. "Every time you ask them questions, they're always a little bit short in the amount of information they release," says Reina Maruyama, a Yale University particle physicist and spokesperson of DM-Ice, one of the experiments that is designed to reproduce DAMA. She notes that DAMA has never moved its detectors to a different location, which would help eliminate systematic noise, or expanded its collaboration to get input from an outsider's perspective.

Bernabei, who declined requests for a phone interview, wrote in an email that DAMA's website (<http://people.roma2.infn.it/~dama>) lists multiple peer-reviewed studies that exclude potential systematic errors.

Despite frustrations over DAMA's perceived lack of communication and transparency, "nobody considers it a statistical fluctuation anymore," Maruyama says. Theorists have proposed that muons, neutrons, and neutrinos could masquerade as dark matter, but no explanation has stuck. Although researchers from the Large Underground Xenon experiment and other ongoing competing efforts say that their null results rule out DAMA's findings, it's possible that dark matter interacts differ-

ently with sodium than it does with, say, xenon.

Road to confirmation

Some scientists recently explored setting up sodium iodide-based dark-matter experiments of their own. But they ran into a roadblock: The DAMA collaboration had requested that Saint-Gobain keep its crystal-growing and material purification methods confidential and not produce sodium iodide for any other experiment. "That's a weird thing," Calaprice says. "You think you'd want someone to confirm the result."

Ouspenski verifies the initial exclusivity agreement but says it ended years ago. The real issue, he asserts, is money. "Other groups didn't find the necessary financial resources for this," he says. Ultrapure sodium iodide is expensive, he adds, and requires the company to take people and resources away from more lucrative work.

But 2016 appears to be the year that other players will finally make a serious run at matching the performance of DAMA's dark-matter detectors. In February, Maruyama's DM-Ice collaboration posted an analysis of data collected from 17 kg of sodium iodide that was buried in Antarctica for three and a half years. Although the crystals were relatively impure, the researchers obtained background-noise measurements that set the stage for a more ambitious experiment with better crystals.

The next stage of DM-Ice will commence this summer at the Yangyang Underground Laboratory in South Korea. COSINE-100, an experiment being con-

ducted in collaboration with the Korea Invisible Mass Search, will deploy 100 kg of sodium iodide that has nearly the purity of DAMA's crystals. Maruyama expects it will take about two years of data to test the DAMA result.

This summer also marks the start of the ANAIS (annual modulation with NaI scintillators) project at the Canfranc Underground Laboratory in the Spanish Pyrenees. The team, based at the University of Zaragoza in Spain, will take data from nine 12.5 kg sodium iodide crystals, whose purities are comparable to DAMA's.

Calaprice says the SABRE project aims to use only about 50 kg of sodium iodide, at least at first. But he is working with Radiation Monitoring Devices of Watertown, Massachusetts, to grow crystals that exceed the sensitivity of DAMA's. The detectors will be placed right in DAMA's backyard, beneath the Gran Sasso mountain.

If all goes according to plan, SABRE would then place another set of detectors at Stawell Underground Physics Laboratory, currently under construction in a gold mine in Victoria, Australia. Although a dark-matter-initiated signal should look the same from both hemispheres, any fluctuation due to temperature or some other seasonal variable would be opposite in phase.

Calaprice says that if dark-matter particles truly are colliding with sodium or iodine atoms, SABRE should be able to tell within about a year. He expects that it would take about three years of data to completely rule out the DAMA results.

Andrew Grant



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