PHYSICS

Dark-Matter Mystery Nears Its Moment of Truth

As announcements go, it was a bit like texting your parents that you're getting married. At a meeting last week, physicists working with an ultrasensitive particle detector deep underground reported three blips that could be particles of dark matter, the mysterious stuff whose gravity binds the galaxies, bumping into atomic nuclei. However, the leaders of the on-going Cryogenic Dark Matter Search (CDMS) issued no press release and stressed that three "events" are too few to claim a discovery.

Nevertheless, other physicists are taking note for two reasons. First, they say, the three events are cleaner and more persuasive than earlier ones CDMS recorded. Second, if CDMS has spotted dark matter, then the beast they've glimpsed—a lightweight version of a so-called weakly interacting massive particle (WIMP)—should show up in other experiments in a year or so. "If this is real, we should know soon," says Neal Weiner, a theorist at New York University in New York City.

CDMS researchers had reason to be cautious. In December 2009, as rumors swirled, they presented two other possible WIMP events. Even though a press release that they issued claimed no discovery, others rolled their eyes. CDMS researchers used certain criteria, or "cuts," to sift signal events from "background" events caused by ordinary particles. If the team tightened its cuts a tad, the two events went away, leading some physicists to criticize CDMS researchers for calling them possible signal events at all. "We felt a bit burned by the experience," says Blas Cabrera, a CDMS member from Stanford University in Palo Alto, California.

This time CDMS researchers soft-pedaled the data. Lurking 713 meters down in the idled Soudan mine in northern Minnesota, CDMS comprises disks of germanium or silicon cooled almost to absolute zero. To look for a nucleus recoiling from a collision with a WIMP, researchers monitor each disk for a pulse of electricity teamed with a pulse of heat. The previous events appeared in germanium data in a version of the experiment known as CDMS-II. (Researchers are now running SuperCDMS.) The new events come from silicon data that CDMS-II collected from July 2007 to September 2008 and were presented on 13 April at the meeting of the American Physical Society in Denver. "They look robust, they look healthy," says Juan Collar, a physicist from the University of Chicago in Illinois, who does not work on CDMS.

Still, the events should be viewed with caution, physicists say. To interpret their data, CDMS researchers must estimate the number of background events that on average they would expect to find in such a data set, which they calculate to be 0.4. That number and other details imply that there's a 0.2% chance the three events are due to background alone, they say. But if the researchers have underestimated the background a little, the significance of the result falls a lot, says Richard Gaitskell of Brown University. "It's like brain surgery," he says, "one little slip and it changes the outcome entirely."

Tantalizing. Physicists working on the Cryogeniz Dark Matter Search have spotted three potential signals of dark-matter particles.

CDMS's results suggest that WIMPs are about eight times as massive as the proton—less than theories had generally forecast—and they roughly jibe with other hints of lightweight WIMPs. In 2010, Collar and colleagues working with an experiment called the Coherent Germanium Neutrino Technology (CoGeNT) in Soudan reported an excess of events that could be low-mass WIMPS. In 2011, researchers working with the Cryogenic Rare Event Search with Superconducting Thermometers (CRESST) in Italy's subterranean Gran Sasso National Laboratory spotted similar signs.

However, an experiment known as The XENON Dark Matter Project in Gran Sasso claimed to have ruled out the CoGeNT and CRESST signals, and a food fight broke out over whose measurements were reliable (*Science*, 3 June 2011, p. 1144). XENON used a detector filled with liquid xenon, an element whose heavy nucleus makes it less sensitive to lightweight WIMPs. So some researchers argued that the XENON team overstated the detector's sensitivity. Conversely, reanalysis of the CoGeNT results suggested that they were mostly background events.

If light WIMPs exist, then several other experiments should soon see them. For example, the Large Underground Xenon dark-matter experiment (LUX) has been assembled 1478 meters down in the Sanford Underground Research Facility in Lead, South Dakota, and should start taking data this year. With its mass of 350 kilograms of frigid liquid xenon, LUX should see thousands of light WIMPs, if they're there. "This is the year of the light WIMP or of its demise," Collar predicts.

The acid test for the entire notion of WIMPs may not be far behind. The idea emerged from a concept in particle physics called supersymmetry, which posits that every known particle has a more massive "superpartner." The lightest of these would be a stable uncharged particle that hardly interacts with normal matter—just the ticket for dark matter. Supersymmetry generally predicts that the particles should be hundreds of times as massive as a proton, and that's mainly the type of particle physicists have sought.

But it hasn't shown up yet. If it doesn't appear in the new tonne-scale detector XENON is building or similar detectors that researchers in the United States hope to build by 2016, then physicists may have to accept that even if WIMPs exist, they're undetectable. "It's going to a critical juncture," says Lian-Tao Wang, a theorist at the University of Chicago. "We are living interesting times."

–ADRIAN CHO

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From the bottom. Archaeologists uncovered the roots of Maya plazas and platforms at Ceibal.

ARCHAEOLOGY

Deep Dig Shows Maya Architecture Arose Independently of Olmec's

The origins of the Maya civilization remain one of archaeology's longest-running mysteries. The Maya continually renovated their imposing pyramids and plazas, burying the earliest architecture under thick layers of stone. So researchers have long struggled to answer a basic question: Did the Maya inherit much of their civilization from the Olmec people in southern Mexico, whose first major ceremonial center, San Lorenzo, arose around 1400 B.C.E.? Or did Maya civilization arise in a more complex way, through interactions with many societies in the region, and only a small helping hand from the Olmec?

A study published this week in *Science* (p. 467) on new data from the Maya city of Ceibal in Guatemala strongly suggests that one key element of Maya civilization—the arrangement of urban ceremonial space—owed little to the Olmec. In a major dig, a team led by archaeologist Takeshi Inomata of the University of Arizona, Tucson, discovered the remains of a ceremonial core, including formally arranged platforms and a plaza, dating to 1000 B.C.E. The platform arrangement is the oldest known standardized ceremonial compound in Mesoamerica—and it predates the first appearance of such architecture among the Olmec. Early Maya may have used the platforms as a stage for ritual performances, and they later transformed this architecture into the Maya lowlands' first plaza and pyramid complex—a hallmark of their later civilization.

The formal spatial plan reveals the Maya's early sophistication, says archaeologist Francisco Estrada-Belli of Tulane University in New Orleans, Louisiana. The study "really opens the door to the idea that the Maya were not the recipients of cultural influence from [the Olmec], as has been suggested," he says.

The Olmec lived in Mexico's Gulf Coast region, and carved massive human heads—likely portraits of rulers—from 20-tonne blocks of basalt. The Maya took up sedentary living after the Olmec did, around 1000 B.C.E.—about when the Ceibal complex was built.

Inomata and his team were drawn to Ceibal by the findings of Harvard University archaeologists who discovered very early Maya ceramics there in the 1960s; they also found a later arrangement of ceremonial space that resembled layouts found at the Olmec capital, La Venta, and at early sites in Mexico's Chiapas region (see map). To examine the origins of this spatial plan, Inomata's team opened major excavations at Ceibal in 2005.

Sinking 12-meter shafts and tunneling below pyramids, the team discovered Ceibal's earliest public architecture: a plaza containing ritual deposits of greenstone axes; an earthen platform that may have held an elite residence; and parts of a characteristic architectural arrangement called an E-group assemblage—a square platform in the west and a long platform aligned north-south. Radiocarbon dating showed that this ceremonial core was built during a transitional period, between the fall of San Lorenzo around 1150 B.C.E., and the rise of La Venta, around 800 B.C.E.

Because San Lorenzo lacks large mounds and pyramids and the later La Venta has a pyramid and plaza complex, Inomata suggests that this kind of ceremonial compound emerged during a time of social ferment when the Maya and many other Mesoamerican groups, including those in the Chiapas area and along the Pacific coast, were communicating and experimenting with new ideas and social orders. "I'm not saying that Ceibal was the origin [of the new architecture], but it was part of a new movement in a broader area," he says.

The dating evidence is sound and "overwhelming," says archaeologist Michael Love at California State University, Northridge. Unpublished results from other sites point in the same direction, he adds.

Not everyone is ready to abandon the model of the Olmec as the major cultural source of the early Maya, however. The new research strongly suggests that the idea of E-groups did not come from La Venta, agrees archaeologist John Clark of Brigham Young University in Provo, Utah. However, such formally aranged ceremonial architecture could still be discovered at San Lorenzo, he says.

Inomata agrees that more excavation is needed but says the finds at Ceibal shed important new light on the early days of Maya civilization. "When some people think about the emergence of civilization, they think of the development of writing and kingship, but this form of spatial organization, and the social organization it implies, probably plays a really critical part," he says.

–HEATHER PRINGLE

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