COMING SOON FROM THE LAB TO YOU

Quantum weirdness in everyday life

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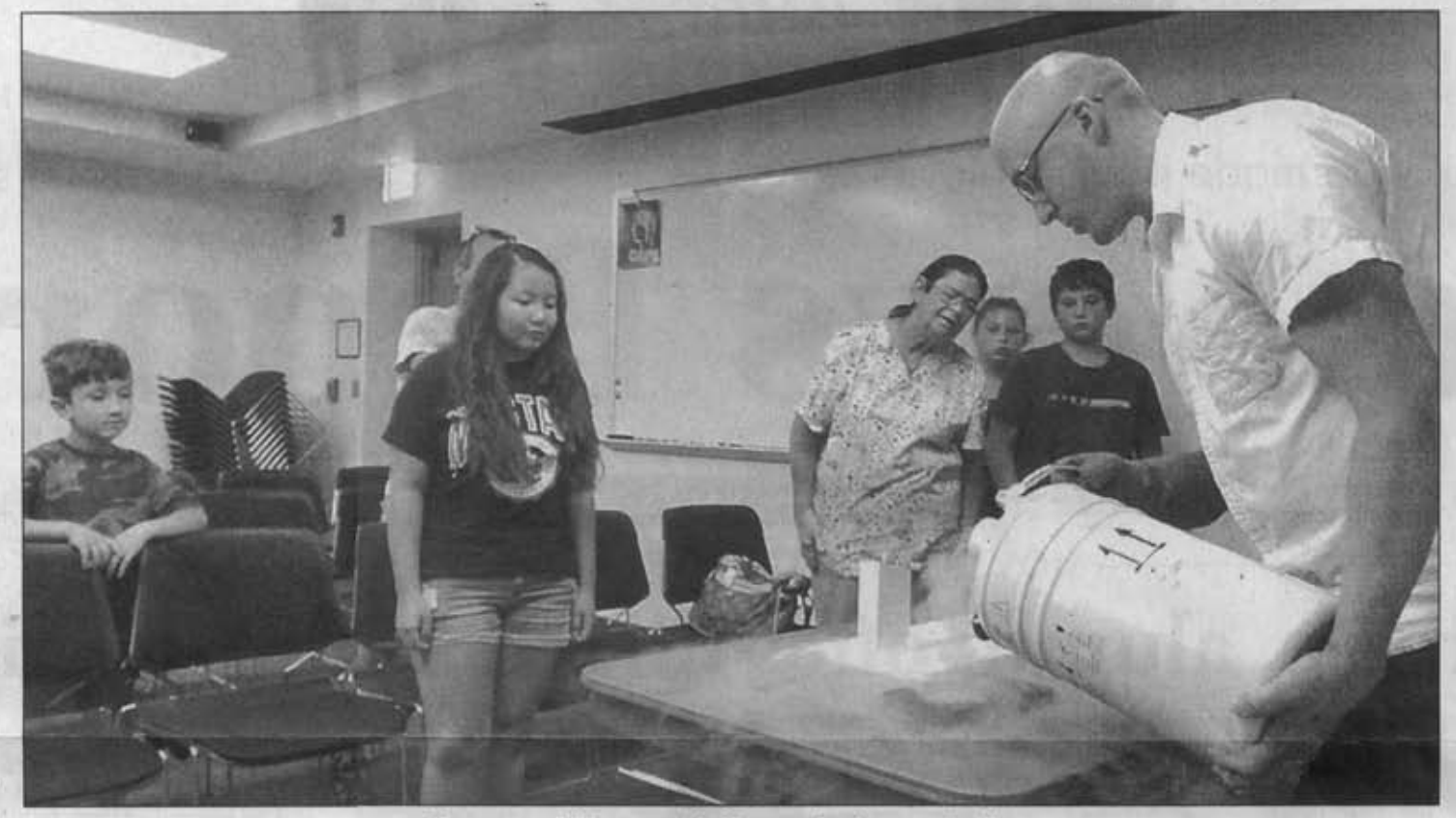

Museum visitors watch Kemper's demonstration.

"If anybody tells you they understand quantum mechanics, they're probably not telling you the truth," Lex Kemper warned his audience at the N.C. Museum of Sciences in Whiteville last Saturday. An assistant professor in the physics department at N.C. State University, Kemper spoke for the "Meet Me at the Museum" series.

Kemper urged his listeners to consider the difference in size between a baseball and the Sun, both of which obey the laws of Newtonian and relativistic physics, and then to consider the unimaginably small world of subatomic particles, which seem constantly to break the rules.

"Very small stuff gets weird," Kemper said.

For instance, "If you toss ordinary tennis balls at the wall, they always bounce back. But if you have quantum tennis balls, maybe one in 5,000 will go through the wall.

"Quantum mechanics is against our intuition. But if you keep on observing that a counterintuitive thing happens, you begin to wonder if maybe your intuition is wrong."

Visitors gathered in the museum's classroom to watch the slideshow Kemper had prepared and to hear his explanation of the surprising behavior of very small objects.

Kemper began with a demonstration. Holding up a small ceramic block, he said, "This is a piece of very fancy stuff." He explained that the crystals of the ceramic material were composed of four elements: yttrium, barium, copper and oxygen. The particles within the crystals were easily influenced to "find buddies and pair up," either by an electrical current or by exposure to extreme cold.

On his table was a bridge-like structure made of neodymium magnets.

When under the influence of cold, said Kemper, "the electrons in the ceramic begin not to like magnets."

He poured liquid nitrogen onto the block and then used tongs to pick it up and release it above the magnet bridge. The block levitated above the magnets and easily flew from one end of the bridge to the other until it warmed up and lost its repulsion effect.

"Cool!" said Frances Chappell, who accompanied Donna Beck and her brother Chase Beck to the presentation.

Kemper agreed. "And the coolest part is that we don't 100 percent know why it does that." He speculated about ways in which humans could someday put the weird electron behavior to work.

In the past, physicists have discovered the odd behaviors of materials, then engineers figured out ways to exploit those oddities, and eventually manufacturers developed products to fulfill consumers' needs, Kemper said.

The 2007 Nobel Prize for physics went to researchers who in 1989 had demonstrated the principle of giant magnetoresistance; MRI machines are based on that concept and contain the same ceramic as Kemper's block. It works better than metal coils because, "it has no resistance, which means it doesn't heat up when a current passes through. If you made that big a magnet using wire, the wire would melt from the heat. But this stuff doesn't melt."

Kemper's next slide illustrated how the electrons in a chip of silicon can lie in a "yes" state that allows other electrons to pass through or can be aligned in a "no" state that blocks the flow. The "yes" and "no" states correspond to the zeros and ones on which computer languages are built. "This is how your phone or computer stores information," he said.

Kemper pointed out how increased understanding of nature had allowed humanity to progress from burning oil for light, at a high energy cost per unit of light produced, to using more efficient incandescent, fluorescent and now LED bulbs.

"Does anyone know what 'LED' stands for?" Kemper asked the audience.

From the back row, George Clark answered, "light-emitting diode."

Kemper explained that the diode is a layered structure in which one layer is oversupplied with electrons while its neighbor is under-supplied. An electric current passing through excites an electron to hop from one layer of the diode to the other, releasing a flash of light along the way.

Kemper predicted that quantum materials research will put still more products in the hands of consumers within "five to 10 years." These will include flexible solar cells that can be worn as part of a piece of clothing for constant recharging of electronic devices, super-light and super-durable construction materials, and materials that can harvest carbon from the atmosphere to reduce the greenhouse effect.

Quantum computers, "a new type of computer entirely based on quantum weirdness," may take 20 years to become available, first to industry and then eventually to individuals, Kemper said.

A native of the Netherlands, Kemper has lived in the United States since 1996. He earned his doctorate from the University of Florida and carried out postdoctoral research fellowships at Stanford University and Lawrence Berkeley National Laboratory. His areas of expertise include superconductivity and complex modern quantum materials. He teaches introductory physics classes at N.C. State University and instructs graduate students in specialized areas such as the work upon which his Meet Me at the Museum talk was based. Kemper describes materials science as "understanding why materials behave as they do and how we can use their properties."

He volunteers with NCSU's College of Sciences outreach program, which he said pulls researchers "out of the ivory tower – we go willingly!" to share programs such as Saturday's talk.

"Scientists like to talk about science," he said. "Teaching scientific literacy is an important part of being a scientist. We all have technology in our lives, but people need to understand how things work. People should be able to think scientifically and ask, 'Does this idea make sense? How can I test it?'"

Kemper's listeners Saturday represented a range of scientific literacy levels, from youngsters just old enough to be wowed by the magnet demonstration to one young woman, Anna Davis, who will begin to study engineering at NCSU this fall. Her hope is to earn a degree in engineering and work in the aerospace field. Her parents, Keith and Susanna Davis, adopted her from China, she said, and her childhood memories include flying to China at age 6 for the family to adopt her sister and attending air shows with her father.

"I like flying," Davis said. At one time she considered becoming a commercial pilot, but then she decided that she was more interested in developing and improving technology, including solar power for aircraft. As Kemper gathered his materials to leave, the two of them discussed string theory, another topic that interested her.

Kemper encouraged Davis in her work. "You're going to be well prepared for college," he told her.

Kemper is the first speaker whom Casey Geer has brought in for the Saturday afternoon talk series since becoming the museum's coordinator of public programs.