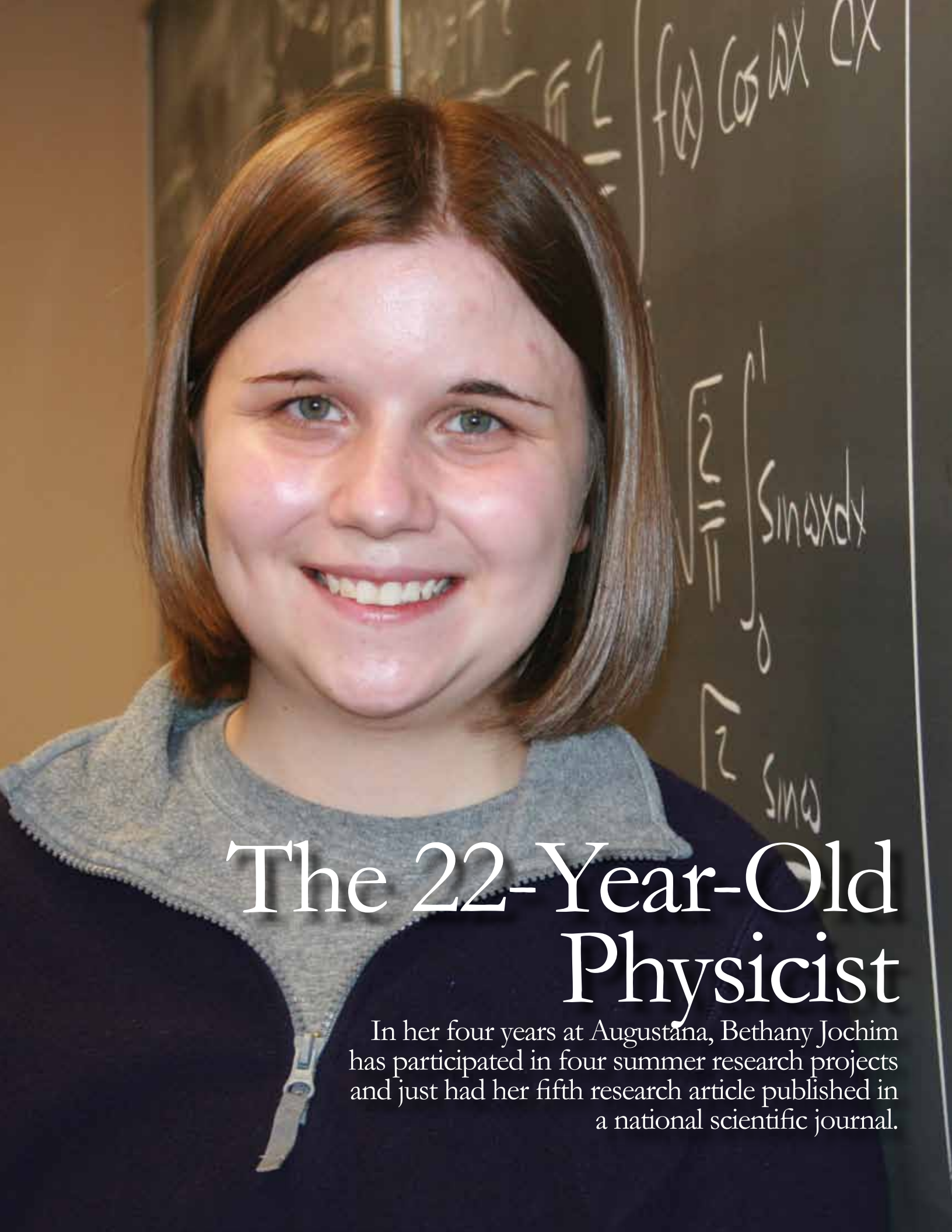

The 22-Year-Old Physicist

In her four years at Augustana, Bethany Jochim has participated in four summer research projects and just had her fifth research article published in a national scientific journal.

In May, scientists and researchers across the globe read an article titled "Velocity Map Imaging as a Tool for Gaining Mechanistic Insight From Closed-Loop Control Studies of Molecular Fragmentation" in *Physical Review A*, a journal published by the American Physical Society.

"We report on the use of velocity map imaging to study the dissociative ionization of CO molecules by optimally-shaped ultrafast laser pulses," the article's introduction says. *"Furthermore, we demonstrate that the acquisition of two-dimensional velocity map images is rapid enough to incorporate directly into the adaptive control loop."*

The article's lead author is listed as Bethany Jochim.

Bethany Jochim is not a widely-known physics researcher – she doesn't even have her Ph.D. In May, she was a quiet, sneaker-wearing, backpack-carrying physics major from Pierre, S.D.

Yet, at just 22 years old, she has already published five articles in scientific journals related to physics research she has conducted at Augustana and at Kansas State University.

'I wanted to learn more.'

Scientific research requires extensive background study, precision, patience and dogged stick-to-itiveness. It also requires a high degree of curiosity.

For Jochim, class of 2011, a curiosity and fascination with science began when she was in high school.

Her physics teacher had spent a class period introducing the Heisenberg Uncertainty Principle, developed by German Physicist Werner Heisenberg in the late 1920s.

"It was all so interesting to me, but I felt like they weren't telling me enough. It sounded so strange and weird and interesting. I wanted to learn more about it. I started researching it more on my own. From there, I became interested in atoms and molecules and the quantum mechanical principles that govern their behavior."

According to Dr. Eric Wells, associate professor of physics at Augustana, Jochim's early interest in science was a sign of what was to come.

"Bethany's the kind of student who works all the problems in the book, even when they're not assigned. That's a sign of a true, born-to-be researcher – someone who has that eternal thirst for knowledge," he said.

After coming to Augustana, Jochim's interest in physics only amplified. Her hard work and intensity paid off when she was accepted to participate in a summer research project after her freshman year.

That summer, and the following one, she worked with Wells researching various processes by which molecules break up in electric fields, either from laser pulses or passing ions.

She spent the summer after her junior year at Kansas State University as a member of the Research Experience for Undergraduates (REU) Program, an initiative supported by the National Science Foundation. Working in conjunction with Wells and Kansas State researchers Dr. Matthias Kling, assistant professor of physics and the leader of the Max Planck Research Group for attosecond imaging at the Max Planck Institute of Quantum Optics in Germany, and Dr. Itzik Ben-Itzhak, professor of physics and director of the J.R. Macdonald Laboratory, Jochim was part of a team that researched how ultrafast laser pulses fragment molecules.

"It's fundamental research now. The hope is that if we can understand how a molecule breaks up in a laser field, we can create a tailored laser pulse that would help produce a product that could have applications in a variety of fields and industries," Wells said. "Today, chemists try to control chemical reactions by manipulating environments. Using a laser, you can manipulate the electrons and do the chemical reaction directly. If we could use a laser pulse, it would be a new way of doing chemical synthesis."

Dr. Eric Wells

Her research experiences led her to contribute to and, in many cases lead, the following five articles, which have been published in scientific journals. Many of the articles include contributions from other Augustana student researchers as well:

- "Examining the Feedback Signals Used in Closed-Loop Control of Intense Laser Fragmentation of CO+," *Physical Review A*
- "Closed-Loop Control of Vibrational Population in CO2+," *Journal of Physics B: Atomic, Molecular and Optical Physics*
- "Velocity Map Imaging as a Tool for Gaining Mechanistic Insight from Closed-Loop Control Studies of Molecular Fragmentation," *Physical Review A*
- "Rapid Formation of H3+ from Ammonia and Methane Following 4 MeV Proton Im pact," *Journal of Physics B: Atomic, Molecular and Optical Physics"*
- "Bond Rearrangement Following Collisions Between Fast Ions and Ammonia or Meth ane," *Application of Accelerators in Research and Industry*

A Significant Accomplishment

Having five articles published as an undergraduate is a major achievement. Yet for Jochim, it's not about the notoriety. It's about sharing information to improve our lives.

"When we're building the article, we develop an introduction that asks, 'why is the problem interesting?' We also outline whether or not other experimenters have encountered similar problems. From there we discuss the experiment and present the data. We talk about any calculations we performed and how we interpreted the data and we wrap up with conclusions and the potential for future work," she said.

Her approach to research and analysis has left positive impressions on those who have worked with her.

"From the interactions I had with her during the experimental campaigns and the data analysis, I can safely say that she is a very bright and ambitious student," said Kling. "I am personally not aware of any other undergraduate student who managed to publish five papers, including first-author papers. This clearly is an impressive indication of her skills."

Ben-Itzhak agrees.

"Usually undergraduate students, and even beginning graduate students, are hardly involved in the writing of their papers. However, Bethany's ability to express herself so clearly in writing is exceptional," he said. "[In addition,] Bethany's self motivation [is] driven by curiosity. During the summer project Bethany conducted last summer with my group, she performed calculations that were needed to interpret the results of our measurements. One late afternoon during a discussion on her calculation, I explained an approach she could apply despite lacking some theoretical information. To my surprise, she showed me the results of this approximation the next morning. This is a good example of her work ethic, her self-motivation and how curious she is to understand the problem at hand – all qualities that will make her an excellent graduate student."

At Augustana, she was named the Rossing Physics Scholar for 2009-2010 and 2010-2011, an award named for Dr. Thomas Rossing, an accomplished physics scholar. She was also among a select group of recipients honored by the prestigious Goldwater Scholarship for the 2009-2010 academic year.

Looking Ahead

This fall, Jochim will begin her graduate studies at Kansas State University where she'll work toward her Ph.D. in physics.

She's been granted a research assistantship and was awarded the Timothy Donoghue Fellowship – an honor that speaks to both her skill and the experience she brings to the table, her mentors say.

"She's too modest to tell you this, but she got accepted to every grad school she applied to. At Kansas State though, because of her experiences at Augustana, she'll come in doing second- or third-year graduate level research during her first year," Wells said.

But before classes begin, she'll have a busy summer. She's been invited to give a talk at the annual meeting of the Division of Atomic Molecular and Optical Physics of the American Physical Society in Atlanta and, she'll also be representing with her research collaborators at a meeting in Belfast, Northern Ireland.

After graduate school, Jochim hopes to teach at the university level and conduct research.

"The research I've been part of and the articles we've published are a testament to how the faculty here [at Augustana] can get students involved. That's a really unique and special opportunity," Jochim said. "In the future, when I do research as a professional, I'd like to involve students in the same way that my professors here have involved me."