Physicists to create more stable gyroscope for Navy

April 27 2005

Gyroscope to be 1,000 times more accurate than existing instruments

Tucked away in a small, cluttered laboratory on Patuxent River Naval Air Station, two physicists spend their days trapping atoms – millions and millions of microscopic atoms.

Dr. Frank Narducci, a physicist at Patuxent River Naval Air Station (NAVAIR 4.5.6.) and adjunct professor of physics at St. Mary's College of Maryland, and Dr. Charles Adler, a physics professor at St. Mary's College of Maryland, are engaged in groundbreaking research designed to create navigation systems 1,000 times more stable than current models for Navy submarines.

Assisting Narducci and Adler in their research are physics students from St. Mary's College, who, during the school year, use the opportunity to work on their senior St. Mary's Projects (SMPs). The students are paid during the summer.

"The students' work is very useful here," Adler said. "We emphasize to them that the work they're doing here is real work; it's not just some project that's not going to do anything for anyone."

In fact, this project has the potential to literally change the course of submarine navigation.

"One of the emerging concerns for the Navy is what if we lose GPS (global positioning system)," Narducci said. "That's how we do all of our navigation right now. So, if the GPS is jammed for some reason, how do you know where you are? You have to rely on your instruments to keep track of your location, but if your gyroscope is drifting or moving around, you don't know where you are."

Enter Narducci and Adler's atomic physics research. The two physicists are using a Magneto-Optic trap to isolate and cool rubidium atoms. The device works by placing rubidium metal into a vacuum chamber. Six lasers are then directed into the chamber to manipulate the atoms, which are isolated and cooled to one millionth of a degree above absolute zero. The isolated atoms will eventually be used to develop the more stable gyroscopes.

"The basic premise for gyroscopes is based on light beams and looking at the interference between light beams as the instrument rotates," Adler said. "That's basically how they measure a rotation. It turns out that you can do the same type of measurement using atoms instead of light beams. But with atoms, you have two big advantages.

"One, the atom is heavy as compared to light beams and because they have mass, they have much greater sensitivity to rotation. Two, atoms have internal structures. We can talk about what goes on inside the atom, and we can use that as a reference to keep things from drifting. So you have the possibility of very sensitive measurements and the possibility of keeping everything stable at the same time by having that standard."

Apart from creating a more stable gyroscope, Narducci and Adler are also using their research, with both hot and cold atoms, to develop a more precise magnetometer. A magnetometer measures the direction and/or intensity of magnetic fields and is often used to locate submarines and mines.

"A submarine is a magnet – a very, very weak magnet," Narducci said. "And you're trying to detect this magnet inside of the earth's very strong magnetic field. Trying to detect a small change in the earth's magnetic field due to the presence of a submarine is a challenging problem, so you need a very precise magnetometer to do that."

The collaboration between Narducci and Adler began three years ago, after Adler expressed an interest in Narducci's work.

"I'd been interested in getting into this field for a while," Adler said. "I thought that the research I'd been doing was getting a little stale, and I was interested in doing something new."

The extra manpower was a boon for Narducci.

"By having Chuck here, we've essentially doubled the number of Ph.D.s working on this project, but I feel like we're getting about four times the amount of work done," Narducci said. "

The students working alongside Narducci and Adler in the lab are given assignments and projects that are critical to elements of the research and must be completed on a deadline-oriented timeline.

"We go to the students and say for this global project to work, we need the following things: a special type of laser or a special type of computer program," Narducci said. "They're tasked to do that, and they're told up front that this is not a project you can put off until a week before your SMP is due. This is state-of-the-art research. It's not physics of 20 years ago; this is physics of today. The students are experiencing that, and they're experiencing what it's like to do research in this type of environment."

Sara Larocca, a senior physics major from Denver, Colo., works in the laboratory on base and is designing a virtual pivot external cavity diode laser for her St. Mary's Project.

"I've learned more in this lab than in any of my classes," Larocca said. "I get a lot more satisfaction in the lab, and I've learned a sense of independence working here."

Collaborative programs, like the one between Narducci and Adler, serve to greatly enhance both the physics students' undergraduate research experiences, as well their future employment prospects at Pax River.

"The College's Office of Career Services has a longstanding recruiting relationship with NAVAIR and the Patuxent River Naval Air Station," said Kelly Schroeder, director of career services at SMCM. "Each year their representatives participate in our annual career day to recruit graduating seniors from scientific disciplines for entry level positions and for summer co-op and internship openings. In addition, the College is currently involved in a new initiative with NAVAIR's Research and Engineering Sciences Department to develop an expanded summer co-op program particularly for mathematics, computer science, chemistry and physics majors. That program is set to kick-off this summer."

For students like Larocca to further benefit from the atomic physics research being conducted on base, Adler is incorporating elements of the research into an advanced upper laboratory course at the College, which is required for all physics students. Previously, the course was designed to either perform a wide variety of labs in all areas of physics, or to teach a useful skill, like electronics.

"The atomic physics is actually a very nice combination of the two approaches," Adler said. "We're changing the advanced lab around to do a number of atomic physics labs, culminating in fact with a demonstration of cold atoms. What's nice about it is that it allows us to learn about a lot of various techniques in atomic physics."

In the lab, students will use a smaller version of the atom trap housed in the base laboratory. Adler recently received funding from the College for the equipment, which will significantly increase the ability to perform atomic physics research at St. Mary's.

"The advanced lab at St. Mary's is focused on atomic physics, but a lot of the techniques are applicable to other types of physics as well," Narducci said. "If students don't want to be an atomic physicist, they can still use all of the skills they've learned and apply them to something else."

Source: St. Mary's College of Maryland

Citation: Physicists to create more stable gyroscope for Navy (2005, April 27) retrieved 25 April 2024 from https://phys.org/news/2005-04-physicists-stable-gyroscope-navy.html