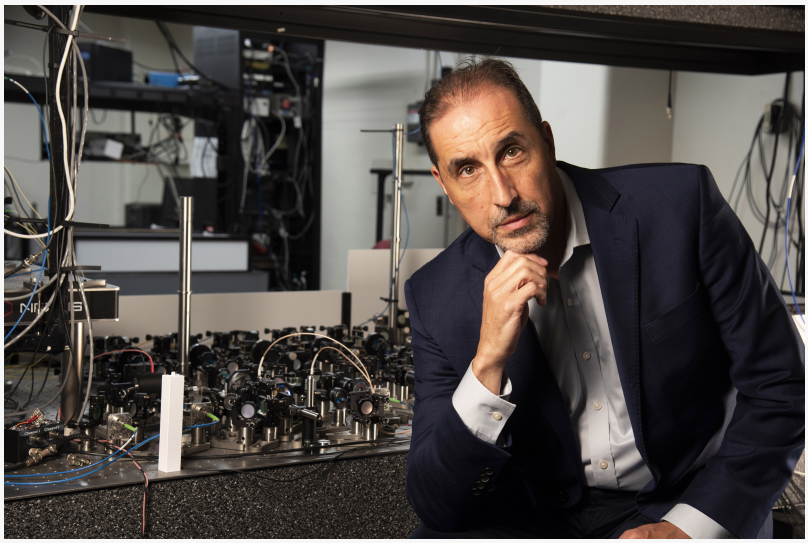
NPS Professor’s DURIP Award Will Take Quantum Research to New Heights

MONTEREY, CALIFORNIA, USA, August 24, 2023 /EINPresswire.com/ -- Naval Postgraduate School (NPS) Professor Dr. Frank Narducci, Chair of the Department of Physics, received a Defense University Research Instrumentation Program (DURIP) award to build what could become the most precise atomic instrument of its kind for applications to quantum sensing experiments in navigation and timekeeping.



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Called an atomic tower, the instrument is expected to have unprecedented sensitivity to acceleration and rotation measurements due to its unprecedented height. NPS research utilizing this instrument has many applications of interest to the Department of the Navy, Narducci explained.

“Most immediately is inertial navigation,” he said. “Due to their inherent sensitivity and long-term stability, atom interferometers similar to this research tower may have implications for developing navigation systems that do not rely on the Global Positioning System (GPS).”

Narducci said the initial version will be a fully functional precision research instrument, approximately 12 feet (4 meters) high, slated to come online this summer. The final version, measuring nearly 100 feet (30 meters) in height, should be installed during the next year.

The technology is very similar to today’s atomic clocks, which keep time to an accuracy that enables our modern GPS systems to work – enabling navigation systems for cars and airplanes, assisting emergency crews in locating people, helping farmers be more productive, and supporting modern military applications.

Quantum Science is one of 14 Critical Defense Technology Areas identified by the Office of the Under Secretary of Defense for Research and Engineering (OUSD R&E), which also funds the DURIP program. The Office of Naval Research (ONR) oversees the Navy's portion of DURIP grants and competitively awards proposals to universities conducting high-quality relevant research addressing naval-unique needs.

"DURIP investments build the research infrastructure needed to fill gaps in our knowledge necessary to develop new capabilities," said Robert McGahern, the DURIP program manager at ONR. "Basic research is the source of future competitive advantage, and conducting quantum science work at NPS has the added benefit of their student's military operational insight to inform and focus defense applications."

Narducci added, "Our mission is the graduate education of DOD leaders – our future admirals and generals – and what could be better to teach them physics than a hands-on platform to understand the principles driving quantum-enabled cutting-edge technologies they will one day lead and employ?"

An atomic fountain works by tossing cold atoms up in an ultra-high vacuum system and measuring how long they take to come down using wave properties of atoms that give quantum sensors their extreme precision; everything from the earth's rotation to tidal lunar forces can impact their measurements and need to be taken into account. To toss the atoms, two finely tuned lasers are directed at the atoms, one closer and one further away from resonance (which is the frequency the atom "likes" to absorb).

"If we simply push the atoms with a single laser, the atoms overheat and is the equivalent of trying to toss a vase up by hitting it with a baseball bat," explained Narducci. "What we do instead is come at the atoms with the two lasers, one from below, one from above. We then very carefully change the frequencies of the laser beams so that the one above is just a little less effective than the one below. This has the effect of gently tossing the atoms up. We are working with atoms that are quite delicate and so all our lasers are very low power."

Finding a location for the tower involved a clever application of reutilizing a former elevator shaft in the tallest building on the NPS campus, Spanagel Hall.

"The 'baby version' we will soon have will allow us to get the kinks out and demonstrate its capabilities," said Narducci. "With the equipment enabled by the DURIP, it will go all the way from the basement floor to the top of the building where construction attributes unique to the elevator shaft enable the stability and precision we seek."

Narducci has been conducting research in the field of light-pulse atomic interferometers for application to quantum sensors such as gyroscopes and accelerometers. The DURIP enables new equipment necessary for the tower's success such as a "red" cooling laser system, magnetic

shielding, a second atomic source and instrumentation for the web server.

“The work being conducted by Professor Narducci is an excellent example of the benefits of basic research in support of national defense,” said Dr. Kevin B. Smith, NPS Vice Provost for Research. “This research is advancing our state of knowledge about quantum sensing in general but is also being pursued in the context of advanced sensors and the development of precision navigation and timing instrumentation, which is critical for future systems employment in contested environments. This combination of cutting-edge basic research coupled with a defense focus is what defines the unique educational experience for our NPS warrior-scholars.”

Designed as a “user facility” with both on-site and virtual access planned, the instrument will be completely automated and configurable via a web-based interface to connect the Naval Research and Development Establishment (NR&DE) and partners involved. In this manner, Narducci expects the tower to play a major role in the advancement of atom interferometry research in general, and in gyroscope, gravimeter, accelerometer and clock research specifically.

“New knowledge for quantum-based techniques and technologies is hard-won,” said Roberto Diener, who leads the Quantum Information Science program at ONR. “Narducci’s research is an important component of ONR’s work, and this atomic tower will help contribute to the foundation of quantum innovation relevant to our naval forces.”

Ultimately, the atomic tower will be in the hands of NPS warrior-scholar students and faculty who will be learning and working on it, offering unparalleled education and research opportunities.

“We don’t expect to make everyone an expert in quantum mechanics,” Narducci added. “But our students will have a much better feel for what a qubit is and what a quantum computer or quantum sensor can really do, and what they can do with it. I look forward to the discoveries ahead.”

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