Researchers detail how antineutrino detectors could aid nuclear nonproliferation

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Patrick Huber a professor in the Virginia Tech Department of Physics, Credit: Virginia Tech

Patrick Huber, a professor in the Virginia Tech Department of Physics, has co-authored an article that describes the potential uses and limitations of antineutrino detectors for nuclear security applications related to reactor, spent fuel, and explosion monitoring.

The article appears in the latest issue of *Reviews of Modern Physics*. In the paper, the scientists review current and projected readiness of various antineutrino-based monitoring technologies. Huber's co-authors include Adam Bernstein and Nathaniel Bowden, physicists at Lawrence Livermore National Laboratory (LLNL), part of the University of California, Berkeley; as well as Bethany Goldblum, also from U.C. Berkeley; Igor Jovanovic, of the University of Michigan; and John Mattingly, of North Carolina State University.

In the paper, Huber and cohorts argue that a tiny particle could offer help for a big problem—the threat of nuclear proliferation. "For more than six decades, scientists have been developing instruments for fundamental physics that can detect antineutrinos, particles that have no electric charge, almost no mass and easily pass through matter," the team said. "Antineutrinos are emitted in vast quantities by nuclear reactors, and since the 1970s, scientists have considered turning antineutrino detection into a tool for nuclear security."

With advances by scientists at LLNL and other institutions, researchers are moving closer to deploying technology to remotely monitor these subatomic particles from nuclear power plants at long distances. Such a breakthrough would allow them to warn international authorities about the illicit production of plutonium, a key material for nuclear weapons. It also could help with verification of existing and planned treaties that seek to limit nuclear weapons materials production worldwide.

Antineutrinos, the antimatter counterpart to neutrinos, are produced in nuclear power plants when the fissile materials of uranium and plutonium break apart, creating fission products that emit antineutrinos in the process.

"At close range from a reactor, antineutrinos allow the measurement of plutonium content and the production rate," said Huber, director of the Center for Neutrino Physics at Virginia Tech and a member of the Virginia Tech College of Science faculty. "This capability would provide high-level assurances of treaty compliance while being less intrusive to the facility."

The study was initiated as part of an ongoing research effort led by LLNL and supported by the National Nuclear Security Administration's Office of Defense Nuclear Nonproliferation Research and Development. Huber and team contend that advances in applied antineutrino physics have the potential to strengthen the existing Treaty on the Nonproliferation of Nuclear Weapons, which provides a framework for facilitating the peaceful use of nuclear technology while reducing nuclear weapons proliferation risks through safeguards, monitoring, and verification.

In their paper, the researchers see potential for three applications of antineutrino technology—near-field nuclear reactor monitoring, far-field monitoring, and monitoring spent nuclear fuel. They conclude that antineutrino technology stationed within about 100 meters of a nuclear reactor could ensure that nations are not making and diverting weapons-usable material under the cover of civilian energy production. By measuring the quantity of antineutrinos produced during a set period, it is possible to approximately quantify the amount of plutonium or uranium in a reactor.

In the area of far-field monitoring, the researchers also said technology for detecting nuclear reactor activity at discovery or exclusion at ranges of 120 miles is possible. A third application for antineutrino technology to detect diversion of material could be to monitor the spent fuel that has been used to operate nuclear reactors.

Several of the article's authors are involved in efforts to advance antineutrino detection technology.

Provided by Virginia Tech

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