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P.22

NUCLEAR CHEMISTRY

Detecting nuclear radiation at a distance

Researchers develop a laser-based method that could scale to distances greater than 100 m

The plasma generated by Howard Milchberg's laser (traveling from the left) interacts with the free electrons in the air above a polonium-210 source.

Maintaining international nuclear security requires tracking and monitoring fissile materials, such as plutonium and uranium. Standoff radiation detectors, which can measure radioactivity from afar, play a key role in those efforts. However, the distance at which current technologies can detect radiation is limited. Now a team of scientists led by physicists at the University of Maryland, College Park, has demonstrated the feasibility of a laser-based method with the potential to detect radiation from further distances (*Phys. Rev. Appl.* 2025, DOI: 10.1103/PhysRevApplied.23.034004).

Using an infrared pulsed carbon dioxide laser, project leader Howard Milchberg and his team showed that they could detect low levels of α radiation from a polonium-210 source sitting 10 m away from the laser source. For this proof-of-principle work, Milchberg's team was limited by the length of the laser lab they were working in but they expect the method to be scalable to distances greater than 100 m.

The technique relies on laser physics, Milchberg says, specifically, the interaction between a laser and free electrons. Radiation emitted by radionucleotides interacts with air molecules, generating free electrons, Milchberg explains. A laser can impart energy to those electrons, which then collide with air molecules and liberate more electrons. The process continues, cascading until "you make a little plasma," he says. "It's almost like a little lightning ball right where it happens."

When these tiny balls of plasma form, the laser scatters off them backward toward its source. Scientists can detect that backscatter, Milchberg says. "The more of those little plasma balls there are, the more backscattering you get," he says. "That tells you something about the activity of the radioactive source."

The work is a synthesis of fundamental physics, air chemistry, and nonlinear optics, says John Palastro, a physicist at the University of Rochester who was not involved with this work but has collaborated with Milchberg in the past. While many experiments in theoretical physics promise applications in only the distant future, Palastro says this work is "poised quite nicely to be an application in the near term."

With their CO_2 laser off, group members Anthony Zingale (left) and Stefan Waczynski (right) adjust the optics of an ongoing experiment that aims to refine the group's method of detecting radiation from afar.

CREDIT: HOWARD MILCHBERG/UNIVERSITY OF MARYLAND (BOTH)

The work is "significant progress towards the development of new, potentially more effective standoff radiation detection mechanisms," research scholar Cameron Tracy of the Berkeley Risk and Security Lab writes in an email. The potential uses of such a long-distance detector include improved detection of fissile material in transport hubs and detecting nuclear weapons deployed in new domains, like outer space.

For now, Milchberg's standoff radiation detector is confined to the lab as his team refines the system. Using a different laser source—and strategically cutting a porthole in the wall to provide access to the adjacent hallway—the group is working toward measuring radiation from distances greater than 10 m. Ultimately, he hopes further experimentation and refinement will result in a practical approach to detecting radiation leaking from containers transporting nuclear materials from afar.—FIONNA SAMUELS