How do neutrons interact with reactor materials?

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Main image: silicon carbide tubes from Oak Ridge National Lab. Inset: University of Kentucky Accelerator Laboratory data on the probability of neutrons interacting with carbon over the range of neutron energies important in fission and fusion reactors. Credit: Image of silicon carbide tubes, Oak Ridge National Laboratory; inset image, A.P.D. Ramirez

Many applications rely on global theoretical models of how neutrons interact with nuclei over a wide range of incident neutron energies. These applications range from energy production to homeland security to medical treatments. Scientists develop these models by comparing calculations with experimental data. Excellent agreement between data and theory indicates that the interaction between the neutron and the material is well understood. This process helps scientists gain confidence in their understanding of the nuclear force, and it helps engineers develop safer and more efficient reactors and scanners.

Carbon and silicon are just two such important materials investigated at the University of Kentucky Accelerator Laboratory by a collaboration of scientists and students from the University of Kentucky, the United States Naval Academy, Mississippi State University, and the University of Dallas. The energy and angular dependence of neutrons scattering from these materials reveals regions where scientists can improve theoretical models, especially for excited states in each nucleus, which in turn provides improved models for neutron behavior for many diverse applications.

Nuclear fission and fusion reactors use the elements carbon and silicon as shielding and structural materials. Nuclear engineers also use these elements in fuel and in neutron moderators, which control the speed of neutrons to help maintain chain reactions. Silicon carbide, for example, can be used to clad fuel and as a pellet coating that offers protection from accidents such as the one at the Fukushima Daiichi power plant. Neutrons are the drivers of the nuclear energy production processes. This makes understanding how neutrons scatter from all reactor materials very important. In this research, scientists investigated the interaction of neutrons with silicon and carbon.

Neutrons scatter from nuclei in ways similar to how balls scatter in a billiards game, except the scattering is ruled by quantum mechanics, as well as by conservation of energy and momentum. Researchers need a detailed knowledge of exactly how these uncharged particles interact with materials because these nuclear data are embedded in modeling and simulation software. These data also determine how well a system will perform. The research team measured the energy and angle dependence of neutrons scattering from silicon and carbon. The results, published as two papers in *Nuclear Physics A*, provide answers that scientists can only uncover through experiments.

More information: A.P.D. Ramirez et al, Neutron elastic and inelastic cross section measurements on silicon from 0.8–8 MeV, *Nuclear Physics A* (2022). DOI: 10.1016/j.nuclphysa.2022.122474

A.P.D. Ramirez et al, Neutron elastic and inelastic scattering differential cross sections on carbon, *Nuclear Physics A* (2022). DOI: 10.1016/j.nuclphysa.2022.122446

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