Optimizing Neutron Thermal Scattering Effects in Very High Temperature Reactors

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Abstract

This project will develop a holistic understanding of the phenomenon of neutron thermalization in the very high-temperature reactor (VHTR). The project team will perform computational and experimental investigations on a selection of current and newly proposed moderators/reflectors. The investigations will include reactor-grade graphite, which is the main moderator/reflector for all VHTR concepts. While this material has been used for many years, its unirradiated and irradiated neutronic behavior in the thermal energy range is not well understood. In addition, the project will investigate new potential moderators. Researchers will study beryllium carbide (Be_2C), as a potential material that could optimize the moderator-to-fuel ratio space in the pebble bed reactor, possibly resulting in approaching the near-global maximum ratio. This project has the following objectives:

1. Address the crystal structure of the reactor-grade graphite moderator to reduce the discrepancy between experimentally measured scattering cross sections and ENDF/B-VII data.
2. Extend the understanding of thermal scattering effects in reactor-grade graphite at the high burnup conditions expected to be reached in the VHTR to address the potentially significant impact of radiation damage.
3. Perform a temperature dependent neutron slowing-down-time experiment in reactor-grade graphite to provide a comprehensive integral benchmark at temperatures ranging from 300-1200 K. In addition, conduct tests of the coupling phenomenon between neutron thermalization effects and neutron interactions with the low lying resonances of heavy nuclides (in this case the 0.3 eV of Pu-239).
4. Introduce the concept of "neutronically tailored moderators" to the design of modern thermal reactors. This approach will use *ab initio* atomistic simulation methods to model neutron scattering effects in moderators at the microscopic scale, tailoring the moderator to influence the thermal neutron environment.