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Fission neutrons to support fusion research

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Developing nuclear fusion as a viable energy source requires demonstrating sustained plasma conditions and validating associated technologies, such as tritium breeding, as well as qualifying structural materials under extreme conditions. Future fusion reactors will operate in an intense neutron environment dominated by 14.1 MeV neutrons from deuterium-tritium reactions. These high-energy neutrons must be utilized for energy recovery and triggering nuclear processes such as neutron multiplication and tritium production from lithium. At the same time, they will cause significant radiation damage to structural and functional materials, including high-performance steels and superconductors. Therefore, understanding and validating the behavior of these materials is essential for designing robust, long-lasting fusion systems.

Although fusion-specific neutron sources are limited, fission reactors provide accessible, well-characterized neutron spectra ranging from fast (~2 MeV) to thermal (~25 meV). This enables targeted experimental investigations. Such studies include research on radiation damage in structural materials beyond the first wall, helium accumulation and blistering effects in steels, neutron multiplication, tritium breeding in specific blankets, and advanced component degradation, such as that of high-temperature superconductors, under irradiation.

There are experimental opportunities available at various facilities, including the MEDAPP beamline at the FRM II. The MEDAPP beamline offers a fast neutron flux of 10^9 n/(cm^2 s) over areas larger than 10×10 cm^2. Despite its relatively moderate flux, the accessibility of MEDAPP makes it attractive for systematic investigations. Complementary neutron scattering techniques, such as wide-angle and small-angle diffraction, enable characterizing radiation-induced defects and helium accommodation at the microstructural level. In addition, material test irradiations in specialized test facilities like the BR2 at SCK•CEN in Belgium can reach fast neutron fluxes exceeding 10^{14} n/(cm^2 s), enabling accelerated neutron damage studies. These already available capabilities for fast fission neutrons provide a powerful foundation for experimental research on fusion materials and tritium breeding.

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