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Unique capabilities of neutron imaging in analyzing structural components in fusion reactors

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Building a fusion reactor places the structural components, particularly the plasma-facing wall, under enormous mechanical and thermal stress while being bombarded by high-energy radiation. Developing and characterizing materials able to withstand these stresses is a crucial step in building and operating a nuclear fusion reactor.
Neutron imaging is a uniquely capable technique for analyzing the materials used in the plasma-facing wall as well as in the structural components. Due to their interaction with the atomic nucleus, neutrons penetrate deeply into these materials and enable the visualization of sub-millimeter-sized pores as well as the distribution of hydrogen in the material.
Using advanced imaging techniques, further contrast modalities can be unlocked. In the case of plasma-facing walls and structural components, additional information about the microstructure can be extracted by mapping the scattering under ultra-small angles which provides insight into the distributions of porosities in the sub-micrometer regime and the formation of cracks. By also analyzing the energy-dependent transmission, the grain and stress distribution, as well as phase transitions, are mapped.
In our contribution, we will illustrate the versatility and power of neutron imaging in materials research in general and fusion research in particular using selected examples.

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