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Limited-view tomography reconstructs fuel density distribution during fusion reactions FREE

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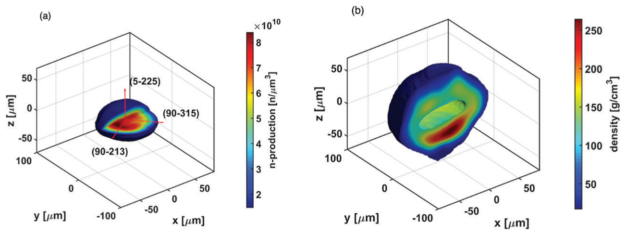
Using images of the primary neutron signals, researchers were able to determine the deuterium-tritium fuel density distribution during fusion ignition – an important step for optimizing fusion processes.



The local deuterium-tritium fuel density plays a crucial role in igniting fusion in inertially confined thermonuclear fuel. The difficulty of accurately determining this density poses a challenge in fusion research.

By computing the local scattered flux based on images using primary neutrons and “downscattered” neutrons (neutrons that have lower energy due to elastic and inelastic collisions) during a deuterium-tritium fusion reaction, Volegov et al. demonstrated a limited-view tomography method for determining the local deuterium-tritium fuel density.

Within the inner deuterium-tritium fuel region, known as the hot spot, the reaction between the deuterium and tritium produces neutrons and alpha particles. The neutrons can either leave the hot spot without scattering or can scatter off the deuterium and tritium ions and lose energy, while the alpha particles heat up the surrounding cold fuel.

“By measuring where the lower energy neutrons emerge from the fuel and by knowing where the neutrons originated from, we can determine where the deuterium and tritium ions were that caused the scattering and, hence, the density of the fuel,” said author Steven Batha.

At the National Ignition Facility (NIF), three primary images are taken of the non-scattered neutrons, as well as one image of the downscattered neutrons. With these four measurements, the researchers used their limited-view tomography procedure to determine the three-dimensional density distribution of the fuel core. Though the method is not able to fully resolve the internal structure of the region, its overall characteristics – such as its shape, size and density – are well described.

The method is already in place at NIF, where an additional detector for downscattered neutrons is being commissioned at a different angle to improve its resolution and better understand fusion performance.

Source: “Density determination of the thermonuclear fuel region in inertial confinement fusion implosions,” by P. L. Volegov, S. H. Batha, V. Geppert-Kleinrath, C. R. Danly, F. E. Merrill, C. H. Wilde, D. C. Wilson, D. T. Casey, D. Fittinghoff, B. Appelbe, J. P. Chittenden, A. J. Crilly, and K. McGlinchey, *Journal of Applied Physics* (2020). The article can be accessed at https://doi.org/10.1063/1.5123751.