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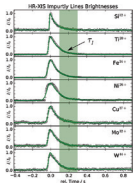
The finding contradicts conventional neoclassical theory for impurity transport.



Results from the Wendelstein 7-X stellarator in Germany have generated excitement surrounding the potential applicability of using this type of fusion reactor for power generation.

The stellarator's operation principle relies on specially made superconducting magnets wrapped around a twisted vacuum vessel to confine ionized hydrogen plasma. One main challenge is figuring out how to prevent the accumulation of highly charged impurity ions, which could rise toward the center of the plasma and cause radiation power loss.

When the plasma temperature reaches 100 million degrees, impurities are unavoidable because the hot particles at the plasma's edge sputter impurities when they interact with the walls of the divertor and diagnostic units.

To better understand how well impurities become trapped inside the plasma, Langenberg et al. studied the transport properties of the most common materials in a stellarator, namely silicon, titanium, iron, nickel, copper, molybdenum and tungsten.

Using the Wendelstein 7-X experiment, the researchers measured the impurity confinement times using a short laser pulse to create a controlled injection of atoms into the edge of the plasmas where they penetrate quickly inward and then slowly decay.

According to theoretical neoclassical predictions, the charge of the highly ionized impurities should significantly influence confinement of the injected impurities. Instead, the authors found that the transport properties were nearly identical for all the impurities in various charge states studied.

The finding suggests a non-neoclassical, anomalous, or turbulent, transport process determines impurity confinement, confirming previous experimental studies that estimated high diffusion parameters for impurity transport.

"The anomalous transport, which effectively prevents impurity accumulation, could be especially beneficial for the planed long pulse operations in future W7-X experiments," Langenberg said.

Source: "Charge-state independent anomalous transport for a wide range of different impurity species observed at Wendelstein 7-X," A. Langenberg, T. Wegner, N. A. Pablant, O. Marchuk, B. Geiger, N. Tamura, R. Bussiahn, M. Kubkowska, A. Mollén, P. Traverso, H. M. Smith, G. Fuchert, S. Bozhenkov, H. Damm, E. Pasch, K.-J. Brunner, J. Knauer, M. Beurskens, R. Burhenn, R. C. Wolf, and W7-X Team, *Physics of Plasmas* (2020). The article can be accessed at https://doi.org/10.1063/5.0004462.