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Not All Ions in Tokamaks Go with the Flow

New measurements reveal that main-ions flow much faster than impurities at plasma edge.

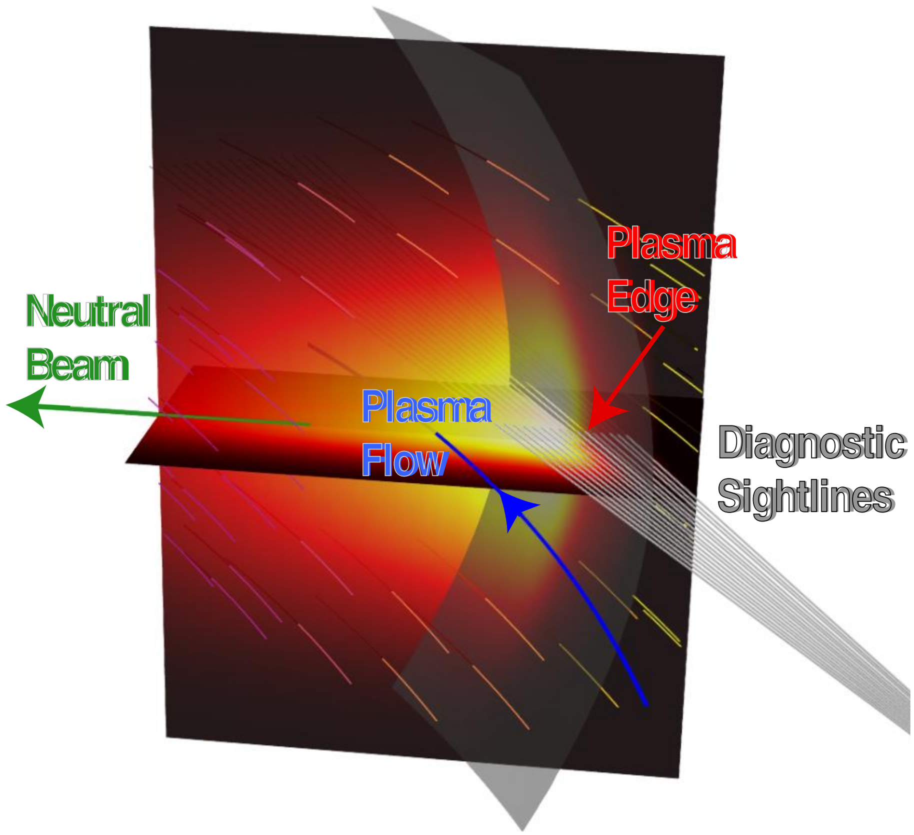

Image courtesy of Shaun Haskey

Simulation of plasma flow measured by injecting neutral deuterium beams into the hot plasma. Diagnostic sightlines (gray) measure the flow of deuterium along the plasma edge from the Doppler shift of the spectrum produced by beam interacting with the plasma.

The Science

Scientists from the Princeton Plasma Physics Laboratory working on the DIII-D National Fusion Facility, in cooperation with scientists at General Atomics, are making new direct measurements of the bulk plasma (deuterium ion) flow near the boundary of hot fusion plasmas. The method is a breakthrough as previously, the bulk plasma flow was inferred from the flow of impurities, which is unreliable near the plasma edge. The spectroscopic measurements of deuterium rotation reveal that the plasma flow velocity can be considerably higher than calculations based on the flow of carbon impurities in the plasma. Scientists from PPPL working on the DIII-D facility obtained the new measurements after installing new optics to collect the light emitted from the plasma deuterium ions intercepting the neutral beams, and performing computationally intensive three-dimensional simulations that allow for quantitative interpretation of the complex multi-component photoemission spectrum.

The Impact

The direct measurement of the bulk plasma flow is providing researchers with unprecedented information on the mechanism of flow generation in fusion plasmas. Rotation is beneficial in fusion plasmas, and experiments like DIII-D often generate rotation through the injection of neutral beams that spin up the plasma. However, a fusion reactor will have a relatively weak source of external momentum and so it is particularly important to understand the mechanism of observed self-generated flow and its implications in future reactors like ITER. The fact that the bulk plasma flow is higher than expected based on impurity measurements is potentially good news for ITER as less self-generated flow will be needed. Future research will use these measurements to develop improved theories of plasma flow in fusion reactors.

Summary

New spectroscopic measurements combined with state-of-the-art spectroscopic simulation provide for the first time a glimpse of the rotation of the bulk (deuterium) plasma in a fusion device. The observed rotation at the plasma edge is substantially higher than previously thought based on impurity measurements. The high rotation is potentially good news for ITER and future reactors as plasma rotation is beneficial for fusion performance, both for stability and confinement.

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Publications

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