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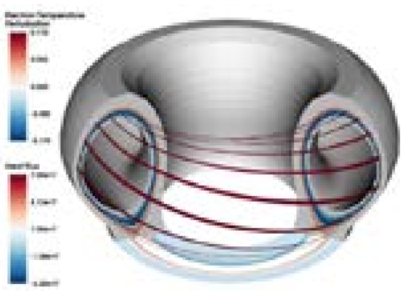
Modeling tokamak boundary plasma turbulence and its role in setting divertor heat flux widths

The success of fusion experiments in ITER (International Thermonuclear Experimental Reactor) will require demonstrated reliability in the plasma facing components (PFCs) to sustain the required pulse lengths. Understanding the physics of the scrape-off layer (SOL) width outside the magnetic separatrix is a crucial problem that must be solved in order to design a successful fusion reactor, as pointed out by the 2015 US Fusion Energy Sciences community workshops on Plasma-Material Interaction (PMI) and transients. The dominant view is that the Goldston "heuristic drift" model determines the peak heat flux. This model relies on magnetic drifts for ions and anomalous transport for electrons, but the anomalous transport mechanisms are not well understood and may depend on which edge transport regime the tokamak is operated in. In this work, massively parallel BOUT++ simulations are used to investigate the nature of SOL transport in multiple international tokamaks, such as C-Mod, DIII-D and EAST. Nonlinear simulations find saturated modes localized at the outer mid-plane that are similar to the quasi-coherent modes; characteristics such as frequency, wavenumber, phase and fluctuation amplitudes are compared with probe and Phase Contrast Imaging measurements on the C-Mod enhanced *D* H-mode discharges. The heat flux transported to divert or displays a width that is within a factor of 2 of the profile measured by IR camera and probe measurements. The parallel electron heat fluxes onto the target from the BOUT++ simulations of C-Mod, DIII-D and EAST follow the experimental heat flux width scaling of the inverse dependence on the poloidal magnetic field with an outlier. This shows that blob-like turbulence is likely to play an important role in present devices, particularly for electrons. Further turbulence statistics analysis shows that the blobs are generated near the pedestal peak gradient region inside the magnetic separatrix and contribute to the transport of the particle and heat in the SOL region.



BOUT++ simulations reveal the dynamics of filamentary eruptions of hot plasma from the edge in a tokamak fusion experiment.

Biography

Xueqiao Xu has his expertise in Plasma Physics and Controlled Nuclear Fusion. He has completed his PhD in 1990 from the University of Texas at Austin. He is a Principal Physicist at Lawrence Livermore National Laboratory and Guest Professor of Peking University.

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