Seminar

Institute for Plasma Research

Title: Investigating radiated-power asymmetries in low aspect ratio fusion plasmas

Speaker: Dr. Kajal Shah
Princeton Plasma Physics Laboratory, Princeton, New Jersey

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Time: 03:30 PM

Venue: Seminar Hall, IPR

Abstract

In this work, we have investigated 2D distributions of impurity densities and radiated power asymmetries caused due to both plasma rotation and the cooling rate dependence on temperature profile, for the cases of Spherical Tokamak Advanced Reactor (STAR) FPP design scenarios [1] and experimental NSTX plasmas, both being low aspect ratio tokamak concepts. Self-consistent calculations of two-dimensional electron, main ion, and impurity ion densities are carried out using one-dimensional input density, temperature, and rotation profiles. In the case of NSTX, discharges with high rotation of ~170 km/s, measured with charge exchange recombination spectroscopy, have been investigated. Rotation-induced charge separation, leading to an electrostatic potential, is calculated iteratively using carbon as the main intrinsic impurity, while testing other higher Z impurities and imposing the quasi-neutrality condition [2]. Strong 2D asymmetry in the core radiated power has been observed due to centrifugal forces. The STAR design, being much larger (R= 4 m), is projected to have a much lower rotation, and is shown to have a low rotation-induced asymmetries in the case of intrinsic W on the order of a few percent between the low field and high field sides. However, another effect not due to rotation but to the dependence of impurity cooling rates on temperature can lead to radiation peaking off-axis, near the plasma edge. This effect is noticeable for Ar in NSTX and for Xe in the much higher temperature projected for STAR (T !,#~32 keV). Further, synchrotron radiation is found to be crucial component of power loss mechanisms for reactor-scale fusion devices. These effects must be taken into account for critical power exhaust solutions in large future fusion devices where deliberate radiation of power from the core or edge is desirable using noble gases [3].

References:

[1] J. Menard et al. NEXT-STEP LOW-ASPECT-RATIO TOKAMAK DESIGN STUDIES, 29th IAEA Fusion Energy Conference (2023)
[2] L. Delgado-Aparicio et al., Rev. Sci. Instrum. **85** 11D859 (2014)
[3] K. Shah et al. Plasma Phys. Control. Fusion **67** 115018 (2025)