Wave scattering by turbulence in fusion plasmas

A. K. Ram[1], K. Hizanidis[2], Z. C. Ioannidis[3,4], and I. G. Tigelis[3]

[1]*Plasma Science and Fusion Center, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA*
[2]*National Technical University of Athens, School of Electrical and Computer Engineering, Athens, Greece*
[3]*National and Kapodistrian University of Athens, Faculty of Physics, Department of Electronics, Computers, Telecommunications and Control, 157 84 Zografou, Athens, Greece*
[4]*Karlsruhe Institute of Technology, IHM, Eggenstein-Leopoldshafen, Germany*

Abstract

The scrape-off layer and the edge region in tokamak plasmas are replete with coherent fluctuations, such as blobs and filaments, and turbulence induced incoherent fluctuations. Radio frequency (RF) electromagnetic waves, excited by antenna structures placed near the wall of a tokamak, encounter this turbulent region as they propagate towards the core. The turbulence scatters the waves and affects their propagation characteristics. Any changes in the wave propagation at the edge have important consequences on the damping of the waves in the core plasma. Spectral and polarization changes due to scattering modify the spatial location and profile of the current driven by the RF waves. We have pursued theoretical studies and complementary computer simulations to elucidate the impact of fluctuations on RF waves. From the full complement of Maxwell's equations for cold, magnetized plasmas, it is shown that the Poynting flux in the wake of filaments develops spatial structure due to diffraction and shadowing. The uniformity of power flow into the plasma is affected by side-scattering, modifications to the wave spectrum, and coupling to plasma waves other than the incident RF wave. The Snell's law and the Fresnel equations have been reformulated within the context of magnetized plasmas. They are distinctly different from their counterparts in scalar dielectric media, and reveal new and important physical insight into the scattering of RF waves. The Snell's law and Fresnel equations are the basis for the Kirchhoff approximation necessary to study scattering of waves by fluctuations.