Scattering of radio frequency waves by edge density blobs in tokamak plasmas

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In magnetic fusion devices, radio frequency (RF) waves in the electron cyclotron (EC) and lower hybrid (LH) range of frequencies are being commonly used to modify the plasma current profile. In ITER, EC waves are expected to stabilize the neoclassical tearing mode (NTM) by providing current in the island region. The appearance of NTMs severely limits the plasma pressure and leads to a degradation of plasma confinement. LH waves could be used in ITER to modify the current profile closer to the edge of the plasma. These RF waves propagate from the excitation structures to the core of the plasma through an edge region which is characterized by turbulence — in particular, density fluctuations. These fluctuations, in the form of blobs, can modify the propagation properties of the waves by refraction and diffraction. We have studied the refractive effect on RF waves due to randomly distributed blobs in the edge region \cite{1}. The waves are represented as geometric optics rays and the refractive scattering from a distribution of blobs is formulated as a Fokker-Planck equation. The scattering can have two diffusive effects — one in real space and the other in wave vector space. In an ITER-type of plasma environment, we find that spatial diffusion is important for EC waves. Since the distance of propagation from the edge to the core of the plasma is of the order of a meter, the EC waves could be deflected away from the intended target region. Meanwhile, the diffusion of EC waves in wave vector space is small. For LH waves the spatial diffusive effects are insignificant but the diffusion in wave vector space is important. This can lead a broadening of the current profile, and, in present-day machines, could explain the spectral gap problem. The theoretical formulation along with relevant results will be presented.

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References

\cite{1} K. Hizanidis, A. K. Ram, Y. Kominis, and Christos Tsironis, \textit{Physics of Plasmas} 17, 022505 (2010).