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An improved rf-sheath boundary condition and implications for ICRF modeling

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Heating and current drive by ion cyclotron range of frequency (ICRF) waves is expected to play an increasingly important role as tokamak research progresses towards the reactor regime. The basic heating and current drive interactions of ICRF waves with the core plasma are well understood, and sophisticated modeling tools are available. In contrast, the ability to understand, predict and control ICRF interactions with the scrape-off layer plasma is relatively poor. To improve the fidelity of global ICRF codes for this purpose, a newly improved sheath boundary condition has been formulated. Extending previous work, which employed a capacitive limit, the new boundary condition generalizes the formulation to a complex sheath impedance which additionally describes the effective sheath resistance at rf frequencies. The latter is important for modeling localized rf power deposition which could potentially cause damaging plasma material interactions. A generalized sheath model has been developed and is described by four dimensionless parameters: the degree of sheath magnetization, the magnetic field angle with the surface, the rf field strength and the degree of ion mobility set by the wave frequency. Complete characterization of the sheath impedance in this parameter space using fits and interpolations is in progress with the goal of a self-contained package that can be used in global rf codes to describe boundary interactions. The special case where the magnetic field is normal to the surface has been completed. The theory conserves energy between sheath dissipation and the waves. In the (low SOL density) case of propagating slow waves, the fraction of power absorbed by the sheath can be calculated. In the opposite regime of evanescent slow waves, the complex sheath impedance provides dissipation for the sheath-plasma wave resonance. Testing and verification of the boundary condition in slab geometry using numerical codes is in progress.

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