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Large RF field amplitudes in the SOL and far-field RF sheaths: a proposed mechanism for the anomalous loss of RF power to the SOL of NSTX

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We propose a new model for the anomalous loss of high-harmonic fast-wave (HHFW) heating power to the scrape-off layer (SOL) of the National Spherical Torus eXperiment (NSTX). A significant fraction, up to 60%, of the coupled HHFW power can be lost along scrape-off layer field lines [1], creating bright spirals of heat deposition on the upper and lower divertor regions [2]. It is important to determine the underlying mechanism because, with 20 MW of ICRF power planned for ITER, a similar loss of ICRF power may erode the divertor and produce unacceptable impurity levels. We hypothesize that the SOL losses are caused by a two-step process. First, the radiofrequency (RF) field amplitude becomes quite high in the SOL when the right-hand fast-wave cutoff layer is positioned too close to the HHFW antenna [1-4]. Second, these RF fields setup far-field RF sheaths on the divertor tiles and drive an enhanced heat flux into the divertor [5]. We present results from a cylindrical cold-plasma model that demonstrate a class of modes that conduct a significant fraction of their wave power in the peripheral plasma [6]; these modes appear when roughly a quarter radial wavelength fits into the SOL. Experimental evidence for RF rectified voltages and currents is presented, and our analysis suggests that they could produce additional heat fluxes consistent with infrared camera measurements of the HHFW heat flux within the spirals. This suggests that the SOL losses can be minimized, and heating efficiency maximized, through tailoring of SOL density and antenna phasing, which will be an important consideration for high-power long-pulse ICRF heating on fusion devices, such as ITER.

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