Self-consistent modelling of the interactions between radio frequency sheath and waves in 3D with realistic ICRF antennas

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Ion Cyclotron Resonant Frequency (ICRF) induced impurity has raised many concerns since ITER proposes to change the first wall material from beryllium to tungsten. Enhanced DC plasma potential (V_{DC}) due to RF sheath rectification is well known as one of the most important mechanisms behind the RF induced impurities. Our previous work (L. Lu et.al, *Plasma Phys. Control. Fusion* 60 (2018) 035003) considered the impact of both the fast wave and the slow wave on the RF sheath rectification in 2D geometry. It can barely recover the double-hump structure of the V_{DC} poloidal distribution observed in various machines when only the slow wave is modelled using the multi-2D approach which intrinsically assumes poloidal wavenumber k_z is zero. The fast wave on the other hand is found to be more sensitive to a finite k_z and may need to be tackled in 3D. This contribution reports our recent progress on the 3D RF sheath modelling. In this new code, the latest RF sheath boundary conditions (J. R. Myra, *J. Plasma Phys*. 87 (2021) 905870504) and the realistic 3D ICRF antennas are implemented while maintaining the same framework of the 2D code. Compared to the 2D results, the 3D code could well recover the double-hump poloidal distribution of V_{DC} even with the fast wave included. The V_{DC} poloidal modulation found in the 2D full wave simulation has disappeared, which confirms our speculation on the necessity of treating the fast wave in 3D. While the double-hump pattern is robust in the simulation, the specific distribution and the amplitude of V_{DC} are found to be affected by the magnetic tilt angle and the antenna geometry, e.g. the way of connections between coaxial cable and strap, which emphasizes the importance of adopting realistic antenna geometry in the RF sheath modelling. The up-down symmetry of the V_{DC} poloidal structure breaks as the magnetic tilt angle increases. This is explained by the gyrotropic property of the cold plasma dielectric tensor. The spatial proximity effect we identified in the previous 2D simulations is still valid in 3D. Finally, simulation shows the slow wave dominates the RF sheath excitation in the private SOL, while the fast wave gradually takes over when moving to the far SOL region. This code could be a new tool to provide numerical support for ITER impurity assessment and ICRF antenna design.