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Influence of Electron Temperature on Tungsten Impurity Behavior

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Recent experimental observations in KSTAR, following the installation of a tungsten divertor, suggest that electron temperature has a meaningful impact on tungsten impurity behavior. InfraRed Video Bolometer (IRVB) diagnostics show that the highest radiation regions correspond to electron temperatures around 2 keV, and spectroscopic measurements identify W^{+27} as the dominant charge state despite its ionization energy being only 881.4 eV. Tungsten impurities exchange energy predominantly with electrons rather than ions. Additionally, measurements and calculations in other fusion devices have shown that electron temperature, rather than ion temperature, is the key parameter for describing tungsten impurity density and ionization distributions [1]. Therefore, electron temperature should be considered as an important factor influencing tungsten ionization and impurity behavior.

In fusion plasmas, understanding and controlling the behavior of heavy impurities such as tungsten is crucial for maintaining high-performance conditions. While the ion temperature gradient has traditionally been considered as the primary governing factor of impurity transport, the large mass difference between tungsten and background plasma species underscores the importance of electron-driven interactions as well. Therefore, future impurity behavior studies should also take into account the role of electron temperature along with existing understanding.

To further explore these effects, integrated simulations using the TRANSP [2] and Hermes-3 [3] codes are being carried out. Neoclassical transport coefficients obtained from TRANSP are applied to Hermes-3 to extend the simulation domain into the core plasma. Background simulations without impurities have been completed, and tungsten impurity simulations are currently in progress.

In future work, simulations will assess how electron temperature influences tungsten impurity behavior, particularly its ionization states and spatial distribution. The results will be compared with KSTAR experimental data for validation, aiming to provide new insights into impurity dynamics in fusion plasmas.

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