Impurity Dynamics during the ELM Cycle on DIII-D*

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Taking advantage of recent upgrades to the DIII-D charge-exchange recombination (CER) system to allow sub-millisecond time resolution of the impurty density, temperature, and rotation profiles in the plasma edge, the dynamics of impurity explusion associated with type I edge localized modes (ELMs) have been studied. The improved time resolution (up to 3.7 kHz used to date) in combination with the excellent spatial resolution in the edge (<3 mm) provided by the DIII-D CER system have revealed interesting details of the evolution of fully stripped carbon density profile (n_C) during the ELM expulsion and refueling cycle. Of particular note is the observation that the ELM event causes a localized (<4 cm on outboard midplane), rapid (<0.3 ms) expulsion of carbon from a region centered near $\rho = 0.9$. As the ELM size increases, the magnitude of the density drop increases while the width of the expulsion layer does not change appreciably. Coincident with this decrease, the carbon density in the scrape-off layer (SOL) is observed to increase ten-fold with the increase extending at least 4 cm outside the separatrix. Detailed examination of the n_C and ion temperature, T_i, response indicates that the ELM causes a rapid expulsion of particles and heat that is poloidally localized near the midplane. The ELM also causes the poloidal rotation v_{pol} throughout the entire edge region to drop to near zero while the toroidal rotation v_{tor} is reduced to near zero for channels within 1 cm of the separatrix location. Hence, at the end of the ELM event, the radial electric field E_r at the separatrix is dominated by the pressure gradient, which itself is small due to the effect of the ELM on the T_i and n_C profiles. The refueling phase of the ELM cycle starts approximately 3 ms after the beginning of the ELM event. The T_i, v_{tor}, and v_{pol} profiles build uniformly throughout this phase. In contrast, the n_C profile evolution is characterized by two distinct phases. First, a fairly rapid (~5-10 ms) increase in carbon density is observed throughout the edge region with the largest increase occurring in those channels closest to the separatrix. Following this rapid increase, the carbon density near the separatrix begins to decrease slowly while further inside it continues to increase, resulting in a monotonic increase in the carbon density gradient until the next ELM. Since the T_i, v_{tor}, and v_{pol} values change little during this time, the E_r well in the edge region becomes progressively deeper throughout this phase and is suggestive that transport continues to improve throughout the phase between ELMs. Modeling of the ELM dynamics using the B2-EIRENE code is now in progress with the intent of identifying the key physics features that lead to the observed phenomena. In addition, the modeling will focus on identifying the main pathways that carbon expelled from the core is redeposited on the plasma facing surfaces using the available SOL and divertor diagnostics on DIII-D.

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