5th Asia-Pacific Conference on Plasma Physics, 26 Sept-1Oct, 2021, Remote e-conference

EMC3-Eirene simulation of first wall recycling fluxes in Wendelstein 7-X with relation to experimental H-alpha behavior

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Although it is expected that the graphite divertor and baffle surfaces, plotted in dark blue in Figure 1, receive the largest ion fluxes in the Wendelstein 7-X (W7-X) stellarator, the large surface area (47m^2) of the graphite heat shield first wall, plotted in light blue in Figure 1, gives it the potential to be a non-negligible contributor to the total recycling source, even if the ion fluxes to this component are small. To investigate this, the heat shield was implemented in the 3D plasma boundary code EMC3-Eirene [1]. It was found that the heat shield contributes negligibly to the total recycling source (<1% for typical values of cross-field particle diffusion D=1m^{2}s^{-1}) in the standard magnetic field configuration. The recycling fluxes which originate on this component are localized to several small areas (visualized as colored regions in Figure 1(right)) and are relatively insensitive to the value of anomalous cross-field particle diffusion [2]. Post-experimental campaign inspection photos confirm that signatures of plasma-surface interaction are localized to these regions experimentally. These inspection photos are expected to largely reflect the standard magnetic field configuration, which was operated for the largest number of plasma seconds [3].

In addition to these post-experimental campaign photos, there are a number of H-alpha diagnostics with lines of sight to all major graphite components (divertors, baffles, and heat shield first wall) to diagnose the total recycling source as well as the magnitude of the recycling fluxes from each component. It is often assumed that the line integrated H-alpha signal is directly related to the local recycling flux from the viewed surface. The synthetic diagnostic module in EMC3-Eirene [4] was used to test this assumption for the heat shield. It was found that even when the synthetic H-alpha diagnostic was focused on a plasma-surface interaction zone on the heat shield (labeled as AEK41 tilted in Figure 1), the neutral ionization source from the local recycling flux does not significantly contribute to the line-integrated H-alpha emission. Rather, the line-integrated signals measured at the heat shield are determined by neutral leakage from the divertor/baffle region. Viewing areas on regions of no recycling in the simulation show similar magnitudes of line-integrated H-alpha photon flux, providing further evidence that the ionization source is not the result of a local recycling process. Therefore, the assumption that the line-integrated H-alpha emission may be used as a direct relation to the local recycling flux is not valid for the heat shield.

The results show that great care must be taken when dealing with line-integrated H-alpha signals viewing components with low recycling fluxes. Although these signals may be used as part of a total recycling source calculation [5], it cannot be used to localize the distribution of these recycling sources on individual components.

References

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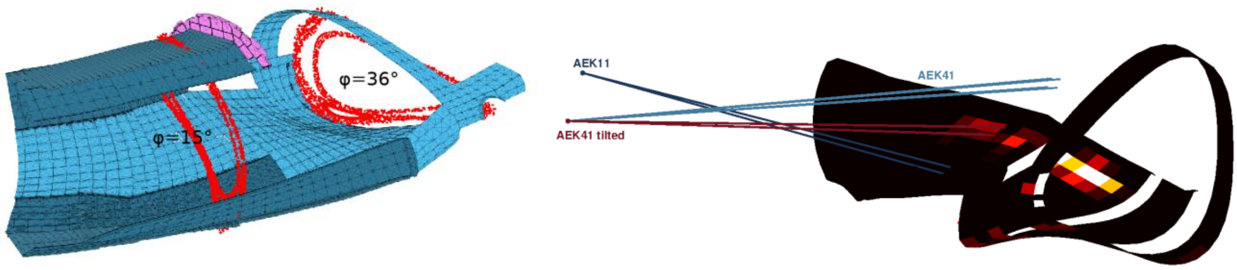

Figure 1: (left) Overview of the W7-X graphite plasma facing components. Divertors/baffles are colored in dark blue. The heat shield is colored in light blue. (right) Viewing areas of the H-alpha synthetic diagnostics, where AEK41 and AEK11 are locations of currently installed experimental lines of sight. Locations of particlue flux incident on the heat shield are shown as colored squares.