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Plasma particle and energy exhaust to and recycling at a tungsten surface

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The divertor and first wall surface not only recycles the plasma particles as returned neutrals but also returns a portion of the impacting ion kinetic energy to the plasma. Unlike carbon tiles, tungsten walls, for the much larger atomic mass, mostly reflect the impacting light ions and hence recycle a majority of the plasma ion kinetic energy. This hinders the plasma energy exhaust and affects the application of external controls for radiative cooling of the boundary plasma. We have carried out a combination of molecular dynamics simulations and plasma kinetic simulations, together with theoretical analysis, to understand how the plasma sheath and the tungsten recycling characteristics, determine the net plasma power exhaust in terms of the density the temperature of the boundary plasma. The new findings include insights on Bohm criterion which predicts a plasma exit speed that is robustly higher than local sound speed in conventional analysis, and on electron heat flux that is a major component of the plasma energy exhaust flux. More importantly, they point out ways for engineering control of the plasma power exhaust.

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