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Atomic and Surface Physics in Tokamak Edge Plasmas

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Material surfaces in fusion machines are subject to intense heat and particle fluxes. As a result, eroded impurities from the walls and divertor targets constitute an intrinsic component of the plasmas; understanding their production and transport relies on broad applications of atomic physics. Various materials have been used for plasma facing components, e.g., stainless steel, inconel, beryllium, tungsten, gold and graphite, and a number of these may be employed in the ITER tokamak. Because graphite tiles are widely used in present day devices, a large fraction of impurity studies have been concerned with the atomic physics of carbon. Influx rates are measured using spectral line intensities together with collisional-radiative models that are built from detailed calculations of electron excitation and ionization rates. In the cold edge region, ion temperatures and flow rates are determined from Doppler broadenings and shifts of spectral multiplets from low ionization stages, which are fitted to complex theoretical profiles that require calculating nonlinear Zeeman effects. Differentiating the mechanisms of production, such as physical sputtering, chemical sputtering, sublimation, etc., involves comparison of molecular and atomic influxes as well as detailed comparison of measured C I line shapes with those modeled for theoretical velocity distributions produced by the different mechanisms.