Atomic and Molecular Spectroscopy in the Scrape-Off Layer of High Temperature Fusion Plasmas

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Atomic and molecular spectroscopy in the plasma edge of fusion plasmas gained importance in the last decade. Three principle categories can be distinguished here: (i) impurity spectroscopy to determine sputtering sources of s and extrinsic seeding species strength, (ii) hydrogen spectroscopy to determine the divertor characteristics and recycling fluxes, and (iii) extrinsic impurities used to probe the plasma in a non-pertubative way. Due to the high temperature of the magnetically confined edge plasma, even in the Scrape-Off-Layer, are dissociation and ionisation processes responsible for the destruction of atoms and molecules and only in detached divertor conditions can recombination become prominent. Electron impact excitation from the ground state and radiative decay are the basic processes though for a set of important atomic and molecular species in fusion plasmas (D, C, He) meanwhile collision-radiative models exist which take e.g. level mixing, metastable, cascades etc. into account. The situation is worse for W which is currently the most important impurity due to the first divertor selection in ITER and the abandon of carbon as plasma-facing material PFM.

We present the actual status in deuterium molecular spectroscopy used to determine the composition of the plasma-facing surface with respect to the atomic-to-molecular flux ratio as well as the isotopic composition of the recycling flux. The identification of T_2 and DT Fulcher-band spectroscopy from the JET Tritium Trace Campaign and the high sensitivity to determine the T content of about 0.1% will be shown. Secondly, the hydrocarbon catabolism had been studied extensively in TEXTOR by injection of all types of hydrocarbons $C_x(D,H)_y$ and the footprint of the injected species in the edge plasma measured. Inverse photon efficiencies for spectroscopic detectable molecules (CD, CD^+, C_2) and atoms/ions D, C, C^+, C^{2+} detected and compared with the HYDKIN code. Comparison of the ionic species with ADAS data revealed up to a factor 5 differences in the efficiency which is likely due to direct excitation in higher state and not the electronic ground state. Moreover, the sputtering yields of the newly selected PFMs in ITER: Be and W and associated experiments with the JET-ILW to determine the erosion yield and molecular destruction in the plasma will be presented. Thereby, chemical assisted physical sputtering (CAPS) in JET limited discharges has been identified to be responsible for a fraction of the total be source. The measurement of CAPS was performed via the A-X band of the Bed molecule in the SOL and simultaneous measurement of BeI and BeII whereas BeII includes both types of physical sputtering. Under constant bombardment of D^+ and high fuel content in the interaction layer (supersaturation) is the release mechanism strongly dependent on the surface temperature. The increase of the surface temperature from 570K to about 800K extinguished the channel for CAPS. About 1/3 of the total yield at impact energy of 75eV is caused by CAPS: its contribution rises at lower energies though still an energetic threshold exists. Finally, experiments with WF6 injection are presented which deliver S/XBs-values to calibrate WI photon fluxes from W limiters at TEXTOR and divertor plates at JET. The first documentation of swift chemical sputtering of W via WD is presented.