Role of line emission spectroscopy in the understanding of the divertor physics of magnetic fusion devices

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The community of scientists involved in magnetic fusion research admits that the divertors of stellarators and tokamaks allow the achievement of high plasma performances in terms of confinement and power. Divertor plasmas can be at different regimes from ionizing to recombining. Ionizing regimes correspond to plasma parameters of about $n_e=10^{19}$ m^{-3} and T_e=10-100 eV and lead to attached divertor plasmas. Recombining ones are reached at lower temperatures T_e=1-3 eV and higher densities $n_e=10^{20}$-10^{21} m^{-3} and lead to detached plasmas [1]. Moreover, according to the divertor target and the wall materials, various species of impurities at different ionization stages can be found in addition to hydrogen (and/or its isotope) neutrals, molecules and ions. Therefore, the accurate characterization of divertor plasmas is a major issue as they strongly affect the performances of the confined plasma. For such a purpose, line emission spectroscopy is a method of choice. It is even the unique technique to characterize detached plasmas for which probe measurements are not reliable. We propose to review the different spectroscopic techniques based on line intensities, line profiles or on both of them for conditions relevant to divertor plasmas at ionizing and recombining regimes with numerous illustrations through concrete comparisons of calculations with experimental measurements from various devices. Illustrations concern for instance the use of high members of the Balmer series of hydrogen in detached plasmas of JET [2], the use of the Hα emission in attached plasmas of Tore-Supra to get valuable information on the velocity distribution functions of the neutrals [3]. Another important illustration concerns the analysis of the carbon emission from a detached plasma divertor of JT-60U in the presence of an X-point MARFE [4-5].

References

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