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Spectroscopic Diagnostic on Magnetic Fusion Plasmas – Application to ITER

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The spectroscopy of magnetic fusion plasmas is the study of electromagnetic radiation emitted from the ionized gas. The radiation from a plasma depends, not only on the properties of the isolated radiating species, but also on the properties of the plasma in the immediate environment of the emitter. Spectroscopy allows one to make a diagnostic of the plasma, which means that one can obtain the density, temperature, and the thermodynamic status from the observed spectra. This requires an accurate modeling both of the plasma and the emitter's radiative properties. The work proposed here is a contribution to the modeling of the radiation emitted by magnetic fusion plasmas for diagnostic purposes. Line shapes and intensities are calculated by taking account of the presence of fluctuating electric fields (Stark effect) due to the individual charged particles, or to their collective motion. The spectroscopic diagnostic of magnetic fusion devices is discussed, with an emphasis on the conditions expected in ITER. An open issue concerns the spectroscopic signature of highly energetic runaway electron beams. Passive spectroscopy methods, which are based on a direct observation of the radiation emitted by the plasma, are convenient because they allow one to get information on relevant parameters (N_e; T_e etc.) without perturbing the plasma. In this work, calculations of Stark profiles for different atoms and ions found in a Tokamak are performed. In some cases, the Zeeman effect due to high magnetic field used for the plasma confinement is also retained. In specific regions of a Tokamak, one has to take account of turbulent plasma fluctuations. This is done with a statistical model for the plasma parameters fluctuations. The possible role of strong Langmuir turbulence is also investigated with a simple model.

Keywords: Spectroscopy, diagnostic, ITER, tokamak, runaway electrons, Stark effect, Langmuir waves