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LOCAL PLASMA DIAGNOSTICS USING TOTAL EMISSION SPECTRA

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Plasma diagnostics by Optical Emission Spectroscopy (OES) is based upon relations between plasma parameters and plasma emissivity. The latter commonly depends on plasma parameters in a non-linear way. As far as real plasmas are neither homogeneous nor steady ones, at the plasma diagnostics one has to find local (in time and space) emissivity values from measured plasma emission spectra. Generally, it is a rather complex inversion problem, which is often simplified supposing plasma volumes have axial symmetry and do not change during the record time. Precise measurements of the parameters and of their real distribution in time and space are problematic, because they demand plasma emission spectra recording at high time and space resolution, as well as tomography technique application is necessary.

Recently the technique was developed for OES measurements of plasma parameters avoiding an axial symmetry approximation (Kurskov, 1990, Bousrih, 1995, Megy, 1995). The technique uses so called Plane Symmetry Approximation (PSA) for the temperature distribution presentation (Bousrih, 1995). The plasma is supposed close to LTE and optically thin Also it has temperature $T<T_m$ (T_m is the «norm temperature» for the spectral component under consideration). The temperature distribution in the observation direction can be approximated as having one maximum and a monotone fall around it. The distribution in other directions can be arbitrary one. In its general form the technique allows to measure parameter maximum values in the observation direction. Displacing observation lines at a chosen (constant) common direction, one can obtain a two-dimensional distribution of the maximum values and present it in a plane perpendicular to the observation line. For every line, the plasma volume limited by the optical aperture of the recording system is supposed to be homogeneous. Temperature distribution in the observation direction is chosen to have a parabolic form: $T(y)=T_0[1+(y/y_0)^\alpha]^{-1}$. Supposing $kT_0<<E_k$ (E_k is upper energy level of the optical transition), very simple relations between directly measured intensity and local plasma parameters at maximum temperature T_0 can be obtained (Bousrih, 1995) and practically used (Megy, 1995, Frugier, 2000).

Further development of the technique (Ershov-Pavlov, 1999, Ershov-Pavlov and Kurskov, 1999) has shown the approach applicability also for OES measurements in fluctuating plasmas. The fluctuations have been considered as time changes of the plasma temperature profile along the observation line. Maximum temperature T_0 is chosen depending on time with other profile parameters being constant, because plasma emissivity depends exponentially on temperature. Two cases of plasma fluctuations have been examined: stochastic and (quasi)periodic ones. The first case is characteristic, e.g., for electric arcs (due to processes on the electrodes) and for turbulent jets, when there are stochastic emission changes and spatial displacements of plasmas across the observation line. The second case can be due to pulsations of the electric power supplied. The development results allow to measure local parameters of inhomogeneous fluctuating plasmas using spectral line intensity and profiles in the plasma total emission. The resulting technique does not require time-resolved recording of the emission. The plasma time behaviour is accounted for using prior observations made at the necessary time resolution.

The numerical and analytical codes have been developed to analyse total emission spectra formation and their dependence on time and space characteristics of the plasma under consideration (Ershov-Pavlov, Stepanov, 2000). Extensive numerical simulations have been performed for emission spectra of the plasma volumes having different spatial distributions and time behaviour of the parameters. Simple relations are found between intensity and profile characteristics (half-widths, shifts) of spectral lines for the plasma local (in time and space) emissivity and the same values in the spectra of the plasma volume total emission recorded during the observation time. For chosen diagnostic lines, the relations factors can be readily calculated and the relations can be applied for local diagnostics of the plasma. The results have been compared with the analytical approximations. Resulting data have confirmed the technique applicability at plasma diagnostics. Also they allow to find limits of the technique use and a range of possible errors at the application.

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