Features of spectral determination of plasma parameters of impulse capillary discharge

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The work is devoted to the analysis and substantiation of the choice of spectral methods for determining the parameters of the supersonic plasma jets, obtained in a pulsed capillary discharge with an ablating wall made of carboncontaining polymer (Perspex glass) in the range of the discharge energies 80-160 J, currents 300-600 A and the discharge pulse durations of 1-2 ms. The plasma of such jets is characterized by a strong spatial inhomogeneity and nonstationarity, which leads to the necessity for careful analysis of its state and the choice of suitable methods for spectral diagnostics. These methods, in particular, can be successfully applied to determine the electron number density and temperature in the paraxial discharge zone [1], in which the conditions of the LTE (ne~1017 cm-3, Te~ 2 eV) are performed with a large margin. But, despite the fulfillment of the LTE criteria for the entire group of excited states of the emitting atoms HI, Cu I, CI and ions C II and Cu II (for levels with *k*≥3), there are a number of circumstances that prevent the reliable determination of the electron temperature by the Boltzmann expomemt (BE) method for a number of named emitters. The violation of the condition Δ*Ek,j*≥*T*e, which is hardly satisfied for hydrogen atoms, is one of such restrictions. Besides that, the growth of *T*e and *n*e leads to the appearance of two additional factors making the BE method unreliable: the reabsorption of Hα line leading to undervalued values of (*nk/gk*)α, and the effect of partial unrealization of weakly bounded states of an atom (ion) with an ionization energy of less than *T*e due to the destruction of excited states by plasma microfields. Both factors prove to be significant, in particular, with respect to the excitation spectrum of CI. The emission spectrum of Cu I is eliminated from these factors. But copper acts as a small and easily ionizable (in comparison with H I) impurity. In the conditions of the Saha-Boltzmann equilibrium, the ionization process Cu$⇄$Cu++e slows down when *T*e increases, that must be considered when evaluating the temperature.

The emission spectrum of singly ionized carbon atom C II is the only group of particles that is free of the above-mentioned causes complicating the diagnostics of *T*e. Its energy spectrum is saturated with strong lines with high values of the excitation energies and transition probabilities. Thus, the presence of closely spaced lines of hydrogen atom Hα and carbon ion C II 657.8 nm, 658.3 nm (16.33 eV) and C II 678-682 nm (22.53 eV), a successful combination of the properties of the emitting components (large energy difference between the excitation levels of the carbon ion lines and the maximum emission intensity in the paraxial jet’s zone) provide the possibility of synchronous data recording necessary for constructing longitudinal profiles of the electron number density and temperature of a spatially inhomogeneous initial section of supersonic plasma jet [2].

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References

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