STABILITY OF ARC DISCHARGES IN VERY-HIGH PRESSURE XENON LAMPS AGAINST ELECTRON TEMPERATURE PERTURBATIONS*

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We study the stability of the energy balance of the electron gas in very-high pressure plasmas against longitudinal perturbations, using a local dispersion analysis. After deriving a dispersion equation, we apply the model to a very-high pressure (100bar) xenon plasma and find instability for electron temperatures T_e in a window between 2400K and $(5.5\text{-}7)\times10^3$K, depending on the current density (10^6-10^8 A /m²). The instability can be traced back to the Joule heating of the electron gas being a growing function of T_e, which is due to a rising dependence of the electron-atom collision frequency on T_e. We then analyze the T_e range occurring in very-high pressure Xe lamps and conclude that only the near-anode region exhibits T_e sufficiently low for this instability to occur. Indeed, previous experiments (e.g., Ref. 1) have revealed that such lamps can develop voltage oscillations accompanied by electromagnetic interference (EMI), and this instability has been pinned down to the plasma-anode interaction. The calculated increment of the instability conforms to the experimental rise time of a single pulse. The above agreement represents an important, although inevitably indirect, confirmation of the theoretical conclusion[2] that T_e in the near-anode layer of very-high pressure arcs is quite low.

There is a similarity between the formalisms of the theory of instability behind multiple anode attachments in high-pressure arcs (Refs. 3,4 and references therein), and of the present theory. However, the mechanisms are different: the Joule heating effect that is stabilizing in one case is destabilizing in the other.

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