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Theoretical investigation of a novel microwave driven ICP plasma jet

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Microwave and radio frequency driven plasmas-jets play an important role in many technical applications. They are usually operated in a capacitive mode known as E-mode. This mode, however, couples considerable power to ions which limits the plasma density and the efficiency and gives rise to negative side effects such as erosion. The inductive coupling, known as H-mode, eliminates these disadvantages and is attractive for large scale plasmas. A novel small scale, microwave driven plasma-jet has been proposed by \textit{Porteanu et al.}[1]. It is operated as an inductive discharge and that has been recently characterized using optical emission spectroscopy (OES) by \textit{Stefanovic et al.}[2]. In this work the proposed plasma-jet is examined theoretically. A global model of the new device is presented based on the volume-integrated balances of particle number and electron density, and a series representation of the electromagnetic field in the resonator. An infinite number of modes can be found ordered by the azimuthal wave number m. The mode m=0 can be identified with the inductive mode and will be called H-mode, the mode m=1 is the capacitive mode and will be called E-mode. By equating the electromagnetic power that is absorbed by the plasma with the loss power, stable operating points and hysteresis effects can be investigated. In a second step the spatially resolved electromagnetic field strength will be considered. All results will be compared to the results of the OES measurements and imagines obtained from CCD-imaging.

[1]Porteanu et al.\textit{Plasma Sources Sci.Technol.}\textbf{22}, 035016 (2013)

[2] Stefanovic et al.\textit{Plasma Sources Sci.Technol.}\textbf{27}, 12LT01 (2018)

[3] Porteanu et al.\textit{Plasma Sources Sci.Technol.} accepted (2019)

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