

P2.3018 Model to self-consistently describe the RF coupling in low pressure high power hydrogen ICPs

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See full abstract here:

<http://ocs.ciemat.es/EPS2019ABS/pdf/P2.3018.pdf>

In ion sources for neutral beam heating systems used in fusion, low temperature hydrogen plasmas are sustained by inductive RF coupling in compact cylindrical discharges of several dm³. The sources are typically operated at low pressures up to 0.3 Pa and powers of 100 kW yielding power densities of 10 MW/m³ to reach plasma densities up to 10¹⁹ m⁻³. The high RF power is close to a technological limit, since high RF voltages promote unwanted arcing between different RF components. It is well known that only the fraction $\frac{P_{\text{plasma}}}{P_{\text{RF}}}$ is absorbed by the plasma, whereas the rest is lost in the RF circuit and other structures surrounding the RF coil. To avoid arcing and thus increase the reliability of the system, optimization of is required by decreasing P_{RF} while holding P_{plasma} constant. In order to do so, the complex interplay of plasma parameter (profiles) and electrical quantities such as has to be known.

depends not only on P_{RF} , but also on geometries of the source and RF coil, gas type (H₂ or D₂), pressure, RF frequency and on the strength of magnetostatic stray fields which are present in the source. Since it is too expensive and time consuming to systematically investigate the impact of all of these parameters on experimentally, a predictive model of the source is needed, that calculates the coupling between the plasma and the RF fields self-consistently.

Therefore, a 1D fluid model has been set up, where the particle and momentum balances for the positive ions H⁺, H⁺², H⁺³ and for the electrons are solved. The RF heating is modeled by the electron energy balance coupled to Maxwell's equations that describe the RF fields. The low pressure regime requires that the electron heating is collisionless rather than collisional. To describe this adequately with a fluid approach, kinetic effects have to be incorporated [1]. The model is experimentally validated at the flexible and well diagnosed small scale laboratory experiment CHARLIE [2] and at the high power RF-driven ion source test bed for negative ions BATMAN Upgrade [3]. Since the dissociation degree is known to be an important parameter in hydrogen and deuterium, the model is then used to study its impact on in both cases.

References

[1] M Turner, J. Phys. D: Appl. Phys.42 194008 (2009) [2] D Rauner et al., RF power transfer efficiency of low pressure ICPs in light molecular gases (this conference) [3] B Heinemann et al., AIP Conference Proceedings 1655, 060003 (2015)

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