Radio-Frequency Wall Conditioning for Steady-State Stellarators

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A discharge sustained by excitation of slow waves at frequencies below the ion cyclotron is used for wall conditioning [1]. The transfer of energy from the wave to the electrons is due to binary collisions. In the discharge plasma is generated with a density substantially less than the density of neutral hydrogen gas. By the interaction of the plasma ions and neutral hydrogen atoms with the wall surfaces volatile substances are formed. The latter can be pumped out from the vacuum chamber. In such a discharge it is important that the plasma density is not high in order to decrease the probability of ionization of desorbed impurities. A similar discharge, but at frequencies higher than ion cyclotron, has been analysed and experimentally tested (see Ref. 2). The advantage of the here considered scenario is the lower frequency that facilitates generator and antenna design and lowers the cost. On the other hand, a high steady magnetic field is necessary that is provided in cryogenic machines. The self-consistent 1D code [3] simulating radio-frequency plasma production in stellarator type machines in the ion cyclotron range of frequencies is used to study such a discharge. The model includes equations for the particle and energy balance and Maxwell's equations. At each time step, Maxwell's equations are solved for current profiles of the plasma density and temperature and the power deposition profile is calculated and transferred to the energy balance equations. For successful start-up of the discharge, it is necessary to provide overlapping of the slow wave global resonances. Following paper [2], this is difficult to provide for low $k_{||}$ resonances. To excite the slow wave, a double frame antenna was used instead of the single frame antenna. This suppresses excitation of long-wave modes. The simulation showed that the discharge can be started and sustained by heating the RF power of 10 kW in a medium-size stellarator.

References

1. V.E. Moiseenko, et al. *Fusion Eng. and Design* **26** (1995) p. 203.
2. V.E. Moiseenko, et al. *Nucl. Fusion* **54** (2014) 033009.
3. V. E. Moiseenko, et al. *Plasma Physics Reports* **39** (2013) p. 873.