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# Power deposition mechanism in helicon plasma sources

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Abstract

Despite the fact that helicon sources are routinely used for production of dense plasmas, the mechanism of power deposition into the plasma is yet to be clearly understood. Helicon sources produce plasma supposedly via helicon waves excited by an rf-antenna. It is crucial that these waves are strongly affected by the plasma density gradient. As a result, the eigenmodes in the discharge are drastically different from those in a homogeneous plasma [1]. We have performed a dedicated experiment to identify the eigenmodes and to examine their role in the power deposition. The Argon helicon plasma is created using a primary rf-generator, while an eigenmode is excited by a secondary low-power generator with variable frequency. Our data confirm the existence of an eigenmode with frequency just below the operational frequency. Measuring the power absorption by the plasma as a function of the antenna frequency for a fixed density profile, we observed a sharp absorption peak down shifted from the primary generator frequency representing an eigenmode excitation. We used a magnetic probe to measure the amplitude of the magnetic field perturbations at the primary frequency downstream from the antenna. Assuming that the eigenmode is a radially localized helicon mode [1], we have used the measured signal to calculate the wave energy density and the corresponding power absorption. This absorption accounts for only a fraction of the power deposited by the primary generator, which clearly indicates that the main part of the power is not deposited via helicon modes.

Motivated by this observation, we have investigated the possibility of power deposition via the excitation of electrostatic waves. The perturbed magnetic field is very small compared to the electric field in these waves, which may explain a low level of signal at the magnetic probe. These waves have a very short radial scale-length and can propagate in plasma even when their frequency is below the low-hybrid frequency, provided that there is a sufficient density gradient. We computed the total power deposited into a long plasma column by exciting electrostatic waves via a finite-length capacitive antenna. The resonantly absorbed power is independent of the dissipation mechanism and its value gives an upper estimate for the power deposition in the experiment. The electrostatic power deposition analysis is being combined with a particle balance analysis [2] to develop a self-consistent description of a helicon plasma source.

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[1] B. N. Breizman and A. V. Arefiev, Phys. Rev. Lett. **84**, 3863 (2000).
[2] B. N. Breizman and A. V. Arefiev, Phys. Plasmas **9**, 1015 (2002).