4th Asia-Pacific Conference on Plasma Physics, 26-31Oct, 2020, Remote e-conference

Time-dependent simulation of two frequencies of lower hybrid power on EAST

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EAST has demonstrated steady-state, fully non-inductive operation [1] using their unique setup of two lower hybrid (LH) systems at 2.45 GHz and 4.6 GHz [2]. Theory predicts that injecting the two LH waves simultaneously would produce higher current drive (CD) efficiency than injection of either frequency alone [3], but evidence for this synergy between the two LH waves has not been observed in the experiments to date. A recent experiment scanned the power fraction from the two antennas while maintaining constant total injected power, at two different density conditions. Analysis of this experiment indicate that simultaneous injection can improve CD efficiency.

The time-dependent evolution of an EAST plasma with simultaneous injection of two frequencies of LH waves has been simulated for the first time using the TRANSP code [4] together with the ray-tracing/Fokker-Planck codes GENRAY [5] / CQL3D [6], which is necessary to evolve the plasma equilibrium and resultant LH current drive self-consistently. In addition to requiring accurate density and temperature profiles for simulation to emulate experiment, it is also found that at low density the injected power spectrum needs to be modified with a tail model in order to reproduce the observed core deposition.

The time-dependent simulations show that, when scanning the injected power ratio of the two frequencies of LH at low density ($n_{e,lin} \approx 2.0 \times 10^{19}$ m^{-3}), a shot with simultaneous injection of 0.6 MW at 2.45 GHz and 0.4 MW at 4.6 GHz achieved an LHCD efficiency higher than 1 MW of either 2.45 GHz alone (by ~39%) or 4.6 GHz alone (by ~8%) injected in similar conditions. However, at high density ($n_{e,lin} \approx 3.3 \times 10^{19}$ m^{-3}), LHCD efficiency was found to monotonically increase with fraction of LH power at 4.6 GHz. The possible operating regimes with synergy and their sensitivity to plasma density and injected wave spectrum will also be investigated, which will further optimize access to long pulse scenarios at high non-inductive fraction.

Work supported by the U.S. Department of Energy, Office of Science, Office of Fusion Energy Sciences, under contract number DE-AC02-09CH1146.

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