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Plasma current generation and ramp-up by the lower hybrid wave using outboard-launch and top-launch antennas on the TST-2 spherical tokamak

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Plasma current start-up without a large flux swing by the central solenoid is a critical issue in fusion research. The lower hybrid wave (LHW) is known to be an effective current drive tool in conventional tokamaks, and it is used in the TST-2 spherical tokamak (ST) device. The TST-2 device provides a unique opportunity to compare outboard-launch and top-launch schemes for plasma current generation and ramp-up by LHW. The Top-launch scheme is expected to have good core accessibility and thus expected to be superior than the outboard-launch scheme. However, one of operational difficulties for the top-launch scheme is the initial vertical position control. The recent operational optimization enabled achievement of the maximum plasma current of 27 kA, which is higher than that obtained by the outboard-launch scheme. By flipping the polarity of the toroidal field, we can realize a scheme equivalent to the bottom-launch scheme. We found that the achieved plasma currents are similar to those with the normal toroidal field direction. This fact indicates that the losses associated with wave reflections at the boundaries are not significant in these cases.
The plasma current increases with the toroidal field strength, and this dependence is quite reasonable when we consider wave accessibility of LHW. If we want to increase the toroidal field strength further, one difficulty we will face is pre-ionization. Normally we use ECH (2.45 GHz/ 5 kW) for pre-ionization, with the fundamental resonance located around the major radius of the top-launch antenna. We will need another pre-ionization tool for higher field experiments. The AC Ohmic operation is one such tool, which requires only about two orders of magnitude smaller flux swing than that for a typical Ohmic discharge. The growth rate of pre-ionization by AC Ohmic operation is rather insensitive to the toroidal field strength. We confirmed that the operation is useful not only for the outboard-launch scheme but also for the top-launch scheme. This fact implies that we obtained a reliable pre-ionization tool which is insensitive to the magnetic field strength.

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