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P4.015 System of 28 GHz ECHCD with beam focusing launcher on the QUEST spherical tokamak

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Electron cyclotron heating and current drive (ECHCD) system with a 28 GHz gyrotron has been prepared for non-inductive electron cyclotron (EC) plasma ramp-up in the QUEST spherical tokamak (ST). Non-inductive plasma start-up using the EC waves is a key issue for advanced tokamak reactor concepts as well as for the ST concept. There are two important aspects of conducting the present ECHCD current ramp-up experiments. One is a beam focusing, and the other is incident polarization control. All elliptical polarization states can be controlled in combination with two corrugated directions of the polarizers with respect to incident planes of the waves. The two corrugated plates were designed and fabricated with careful attention to reduce Ohmic losses by means of high-precision milling, not wire-electrical discharge machining. The two-mirror launcher system has been developed to obtain a narrow beam size of w ~ 0.05 m. In the mirror surface design, the principle of the least propagating-phase was considered. The Kirchhoff integral and the Gaussian optics were used to evaluate the propagating-phases before and after the mirror reflection, respectively. The mirror area should cover a 1% intensity edge of 1.5w in the beam. The relatively large 2nd focusing-mirror with a diameter of 0.37 m was designed and fabricated for sharp beam focusing. The incident beam can be steered from perpendicular to tangential injections. The steering capability with excellent focusing property was confirmed at the low power test facilities. As a new record of non-inductive plasma ramp-up with EC-waves, a highest plasma current of 86 kA was achieved with a focused 230 kW 28GHz-beam. The record plasma current ramp-up efficiency on the incident power in the 2nd harmonic EC scenario was also achieved. The obtained electron density was one order of magnitude higher, compared to the previous experiments with no focusing-beam.

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