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Development of ITER poloidal steering equatorial EC launcher enhancing ECCD performance

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The ITER EC equatorial launcher (EL) has been newly designed to achieve an enhanced electron cyclotron current drive performance based on the dedicated calculations. The millimeter(mm)-wave beam design of EL optimized the mm-wave transmission capability and spatially limited beam path such as the mirrors' dimension and the plug mounted Blanket Shield Module openings has implemented poloidal steering with fixed toroidal angle. The poloidal steering would reduce the Doppler shift broadening so that narrower deposition and full first pass absorption of mm-wave power could be achieved over the range of 0.4<ρ<0.6. The new EL design allows doubling the current drive capabilities as required.
In the new EL design with poloidal steering capability, the beam path design was optimized with maximizing mm-wave beam propagation based on the calculated angular spectrum for both the near field and Fresnel diffraction for the far field. Multi-beams propagated through the beam path are superimposed and transmission efficiency and power profile of the superposed beams in the path were calculated to design the parameters such as the shape and size of both the fixed and steering mirrors, the waveguide set-up configuration and etc ⋯The optimization resulted in power transmission efficiency of 97 % was successfully attained assuming that beams in mixture of fundamental mode, HE11 (90%) and high order mode, HE21 (10%) were radiated from the waveguide. The peak heat load on M1 and M2 and the beam radius at plasma target were 4.95 MW/m^2 and 3.0 MW/m^2, and 25 cm respectively, which compliant with ITER requirements.
The mock-up of the new EL design was fabricated. Only 4 out of the 8 beams (ones in each corner) were used to simulate the envelope of the 8-beam propagation. Beam profile measurement was performed and a good correlation between the design and measured radiation profile with agreement well within a few percent of error was obtained. In conclusion, the optimized quasi-optical mm-wave beam design has resulted in transmission efficiency of 97%, a limited heat flux on both steering and fixed mirrors of less than 3.0 MW/m^2 and 5.0 MW/m^2, respectively. A mock-up of the enhanced EL design has been constructed, followed by the validation of the quasi-optical design with mm-wave transmission. These results assure the doubled ECCD functionality for ITER.

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Author: Dr TAKAHASHI, Koji (Japan Atomic Energy Agency)

Co-authors: Mr ABE, Ganji (JAEA); Dr SHIDARA, Hiroyuki (JAEA); Dr SAKAMOTO, Keishi (Japan Atomic Energy Agency); Mr KOMATSUZAKI, Manabu (JAEA); Dr HENDERSON, Mark (ITER Organization); Mr ISOZAKI,

Masami (JAEA); Dr IKEDA, Ryosuke (Japan Atomic Energy Agency); Dr MORIYAMA, Shinichi (JAEA); Dr KOBAYASHI, Takayuki (Japan Atomic Energy Agency); Dr OMORI, Toshimichi (ITER Organization); Dr ODA, Yasuhisa (Japan Atomic Energy Agency)

Presenter: Dr TAKAHASHI, Koji (Japan Atomic Energy Agency)

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