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The quasi-optical ECRH system of Wendelstein 7-X

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The standard heating method at W7-X is a steady state capable electron cyclotron resonance heating system with ten 140 GHz gyrotrons and an overall installed power of currently 8.3 MW. The fully quasi-optical transmission line to the plasma vessel is the first of its kind. It consists of a section with single beam waveguide (SBWG) mirrors matching the non-perfect Gaussian beam of the gyrotrons to the subsequent section with broadband multibeam waveguide (MBWG) mirrors allowing low-loss transmission of up to 7 beams with a theoretical overall spurious mode generation of less than 0.2 %. All mirrors were aligned with the high power ECRH beam itself, and only two beams were necessary for the adjustment of the MBWG mirrors demonstrating the nearly perfect imaging properties of the imaging MBWG section that is followed by an additional SBWG section to the individual torus window. The overall theoretical power loss to the window is 6 % including diffraction, beam truncation, misalignment, absorption of the mirrors and the atmosphere. It was proven by reflecting a high power ECRH beam with the aid of a corner cube reflector in front of the torus window. Therefore, the beam passes twice the MBWG section to measure its remaining power in the same calorimeter as the input beam. High power operation in air could be successfully demonstrated by several 1-minute-pulses over a beam path length of 120 m and 31 quasi-optical mirrors.
In the plasma vessel a triple beam pass O2 heating scenario makes use of polarization correcting and holographic reflector tiles to allow high density operation beyond the X2-cutoff density of $1.2 \cdot 10^{20}$ </sup> m^{-3} and achieve an overall absorption of 95 %. To finally achieve average beta values of 4 - 5 % and demonstrate the optimization criteria of W7-X, the installed ECRH power will be doubled in the coming years. For this purpose, the number of gyrotrons will be increased from 10 to 12 and the power per unit from 0.9 MW to about 1.5 MW.

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