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First plasma operation of Wendelstein 7-X

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The main objective of the optimized stellarator Wendelstein 7-X (W7-X) is the demonstration of steady-state plasma operation at fusion relevant plasma parameters thereby verifying that the stellarator is a viable fusion power plant concept. The design of W7-X is based on an elaborate optimization procedure to overcome the shortcomings of the concept. After completing the main construction phase of W7-X and successfully commissioning the device, first plasma operation started in December 2015. Plasma operation of W7-X follows a staged approach according to the successive completion of the in-vessel components. During the first operational phase five inboard limiters defined the last closed flux surface. Subsequently, W7-X will be equipped with a test divertor unit and eventually with a steady-state capable high heat flux divertor including active water cooling of all in-vessel components. Integral commissioning of plasma start-up and operation using an electron cyclotron resonance heating (ECRH) and an extensive set of plasma diagnostics, and initial physics studies during the first operational campaign have been successfully completed. Both in helium and hydrogen, plasma break-down was easily achieved. Gaining experience with plasma vessel conditioning, discharge lengths could be continuously extended. Eventually, discharges lasted up to 6 sec, reaching an injected energy of 4 MJ which is twice the limit originally agreed for the limiter configuration. At higher powers of 4 MW and central electron densities of 4.5x10ˆ{19} mˆ{-3}, central temperatures reached values of 7 keV for the electrons and just above 2 keV for the ions. Important physics studies during this first operational phase include the assessment of the heat load distribution over the inboard limiters changing the toroidal phase and amplitude of deliberately applied error fields, impurity injection and confinement experiments including the effect of the rotational transform, and ECRH power deposition and heat pulse propagation experiments. Also a first assessment of the central electron root confinement, 2nd harmonic O-mode ECRH using multi-pass absorption, and the investigation of confinement and stability of discharges with co- and counter current drive (ECCD) have been achieved. This paper will give an overview of the results of the first experimental campaign of W7-X.

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