First-time realization of a stably detached, efficient-particle-exhaust divertor regime in the island divertor at Wendelstein 7-X

O. Schmitz[1], M. Jakubowski[2], R. Koenig[2], M. Krychowiak[2], F. Reimold[2], G. Anda[3], T. Barbui[1], C. Biedermann[2], S. Bozhenkov[2], S. Brezinsek[4], P. Drewelow[2], F. Effenberg[1], D. A. Ennis[5], Y. Feng[2], E. Flom[1], H. Frerichs[1], O. Ford[2], G. Fuchert[2], Y. Gao[4], D. Gradic[2], K. C. Hammond[2], J. Knauer[2], P. Kornejew[2], G. Kocsis[3], T. Kremeyer[1], H. Niemann[2], M. Otte[2], E. Pasch[2], V. Perseo[2], G. Schlisio[2], T. Sunn Pedersen[2], T. Szepesi[3], U. Wenzel[2], V. Winters[1], G.A. Wurden[5], D. Zhang[2], S. Zoletnik[3] and the W7-X team

[1]Univ. of Wisconsin - Madison, Dept. of Engineering Physics, WI, USA - [2]Max Planck Institute for Plasma Physics, Greifswald, Germany -[3]Wigner, RCP RMI, Budapest, Hungary - [4]Inst. of Energy- and Climate Research, Research Center Jülich, Jülich, Germany - [5]Auburn University, Auburn, USA – [6]Los Alamos National Laboratory, Los Alamos, USA

The island divertor concept is an innovative and promising idea to handle heat and particle exhaust in stellarators. At the recently started stellarator Wendelstein 7-X, this divertor concept plays a central role in the device mission to demonstrate reactor relevant plasma confinement for steady-state time scales of up to 30 minutes in the high-performance campaign phase, OP2, starting in 2021. During the recently concluded first campaign with the island divertor, a large step in the experimental qualification of this divertor concept has been made. In discharges heated with Electron Cylotron Resonance Heating of 5-6 MW, central densities in the range of 0.8-1.2 10^{20} m^{-3} have been reached in combination with full divertor heat flux detachment and significant neutral gas compression for the first time. The divertor heat loads drop by an order of magnitude from >5 MW m^{-2} to below 0.5 MW m^{-2} with increasing density, and the compression of neutrals in the divertor reaches at least 30 with neutral pressure in the sub-divertor volume of >8.0 10^{-4} mbar. This is likely compatible with the steady-state particle exhaust requirements for high-performance steady-state operation in OP2. These discharges were held stably detached for up to 30 seconds, which is equivalent to several hundred energy confinement times and beyond the time scales for current relaxation. Electron temperatures above 2 keV in the plasma edge and 5keV in the plasma center were maintained. No impurity accumulation was seen at constant Z_{eff}~1.5 and the stored energy stayed constant at around 600kJ. This contribution will explain the island divertor concept in W7-X, provide an overview of this recently discovered divertor regime, and describe the status of the physics understanding of these results including modeling of these regimes with the EMC3-EIRENE code.

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