Contribution ID: **752** Type: **Poster**

Transport studies during the first campaign of Wendelstein 7-X

Thursday, 20 October 2016 08:30 (4 hours)

The understanding of cross-field transport of particles and energy represents one of the most important challenges on the verge towards magnetic confinement fusion and is indispensable to extrapolate to next-generation devices. The Wendelstein 7-X (W7-X) stellarator, designed to operate quasi steady-state (pulse lengths up to 30min), has been optimized with respect to a reduction of neo-classical transport, low Shafranov-shift, and low bootstrap current to ensure viable divertor operation. The purpose of the first operation campaign, which started in Dec. 2015, was the integral commission of the device and its components in helium and hydrogen plasmas in a limiter configuration using electron cyclotron resonance heating in X-mode polarization with heating powers PH≤4MW. The temporal evolution of the plasma density was monitored by a laser interferometer system and its profile via Thomson scattering. These profile information provide the basis for detailed comparison to neo-classical transport calculations. In preparation for long-pulse operation, dedicated plasma discharges have been devoted to impurity transport studies, using the X-ray imaging system and the HEXOS overview spectrometer to resolve the evolution of Argon impurities injected into the plasma edge. Studies of turbulent transport were not the focus of the first experimental campaign. However, a number of fully-nonlinear turbulence simulation results exist for an entire flux-surface of W7-X. Fundamental characteristics are the influence of the unfavorable magnetic curvature region, which is poloidally highly localized in the W7-X magnetic field configuration, and the influence of local magnetic shear, which leads to an amplitude envelope following the five-fold magnetic field symmetry. Based on detailed profile measurements fundamental considerations about instability growth rates can be made. In addition, an edge-localized correlation reflectometer system on W7-X measures fluctuation spectra and typical poloidal phase velocities, which are compared to the simulation results. This paper summarizes the results obtained in the first operation campaign of W7-X with respect to neo-classical and turbulent transport and it's comparison to theoretical predictions.

Paper Number

EX/P5-14

Country or International Organization

Germany

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Session Classification: Poster 5

Track Classification: EXD - Magnetic Confinement Experiments: Plasma–material interactions; divertors; limiters; scrape-off layer (SOL)