Observations of electron-driven Alfvén eigenmodes in Wendelstein 7-X

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Experiments conducted in the Wendelstein 7-X OP1.2a campaign regularly achieved electron temperatures in the range of 1-4 keV with densities of $1\text{-}4\times10^{19}$ m^{-3} with H and He gas puffing, though pellet fueling was able to substantially increase the density toward the X2 cutoff around 8×10^{19} m^{-3}. Despite the absence of energetic ions, clear signatures of Alfvénic modes were observed in many experiments covering a wide range of conditions. Calculations from the CKA-EUTERPE code suggested that Alfvénic modes identified during the W7-X OP1.1 experimental campaign may have been driven by the gradient of the thermal electron pressure. In this work, we summarize the observations and present the trends compiled over and exhaustive search of all experiments from the OP1.2a campaign. The observed Alfvénic activity falls under two major classes of behavior: modes that are excited during the early plasma within about 100 ms of breakdown, and those that are excited later in the plasma. In the early transient phase, Alfvénic modes tend to be short-lived and with rapid frequency variation, suggesting a sensitive response to evolution of the local equilibrium, perhaps similar to reversed shear Alfvén eigenmodes observed in tokamak experiments. With few exceptions, the Alfvén modes observed at later times are long-lived with steady frequency signatures, and tend to closely track the density evolution. We compare measurements from the phase contrast imaging diagnostic, Mirnov coils, and the soft x-ray diagnostic system (XMCTS).