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He / Ne Beam Line Ratio Spectroscopy to Investigate Plasma Boundary of Wendelstein 7-X Stellarator Fusion Experiment

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Heat and particle transport in the plasma boundary region, also known as the scrape-off layer (SOL) situated beyond the last closed flux surface in a fusion device, significantly influences the performance of the divertor, which serves as the heat and particle exhaust system. In order to optimize the divertor concept, it is crucial to gain insights into the transport phenomena within the SOL, achieved through studying plasma parameters such as electron temperature (T_e) and density (n_e). The Wendelstein 7-X (W7-X) stellarator has ten novel island divertor units intersecting the plasma edge [1]. As a way of measuring the basic plasma parameters in the SOL, diagnostic systems used consist of a gas injection system and multiple high resolution spectrometers installed in the mid-plane and in front of the W7-X divertor. The gas injection system injects helium (He), neon (Ne) or a mixture of both, and the array of spectrometers can measure their respective spectral lines [2]. Line ratio spectroscopy based on a collisional radiative model is used to infer the n_e and T_e. The He beam diagnostic at W7-X has been well validated and extensively used to map the plasma parameters in the island divertor, and the addition of Ne will allow for more accurate mapping of the low temperature regime of the edge (T_e <5 eV) [3] [4]. The temperature and density profile presented here is measured above the horizontal divertor target in various conditions including detached and impurity-seeded plasmas.

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