In the first operation phase of the Wendelstein 7-X stellarator, due to the operational limits on the total input power, only low-density, electron-heated plasmas were produced [1]. These plasmas display peaked electron temperature profiles and positive electric field in the core—a feature well understood in the framework of neoclassical theory. The large core electric field and very low collisionality ($\nu_e \sim 10^{-4}$) places electrons in the so-called $\sqrt{\nu}$ regime [2], which in particular makes the qualification of the neoclassical optimization of the device, based on the reduction of the $1/\nu$ transport [3], not possible in its full extent.

The profile diagnostic coverage of these first W7-X plasmas allowed, nevertheless, the evaluation of the effective ion heat fluxes and confinement times. The effective ion heat flux is here defined as the heat flux through a given flux surface that is necessary to remove the power deposited into the ions (caused, in these plasmas, by collisional power transfer from the electrons) integrated over the volume bounded by that flux surface. In this contribution we will present these estimates for the available range of plasma conditions and magnetic configurations. We will study the dependencies of the effective ion energy confinement time on the configuration, ion collisionality and a proxy of the radial electric field, assessing the main sources of uncertainty and the limitations of the method. The results will be discussed in terms of neoclassical transport and charge exchange losses. Finally, we will discuss prospective ion-heat-transport studies for the next operational phase of the W7-X stellarator, which is meant to develop high-pressure, long-pulse, diverted-plasma scenarios.

References