Diffusion Dominated Transport for a Wide Range of Different Impurity Species Observed at Wendelstein 7-X

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This paper reports on trends for impurity transport with respect to different impurity species as observed in hydrogen plasmas of W7-X. Measurements of the impurity transport times $\tau_I$ [1] show a very similar impurity transport behaviour for a wide range of different impurities under the variation of the atomic number $Z$ as well as the atomic charge $q$ and the charge to mass ratio $q/M$ as shown in Fig.1. The observed marginal effect of the impurity mass and charge state on the transport properties of highly charged impurities is in agreement with theoretic expectations of anomalous, diffusion dominated impurity transport [2], supporting recent experimental findings of anomalous transport with large impurity diffusivities in W7-X plasmas [3,4]. We note that neoclassical transport calculations predict a pronounced $Z$ dependence of the impurity convection $v$. In addition, the neoclassical diffusivities are predicted to be more than one order of magnitude smaller than the observed ones.

The combination of weak $Z$ dependence and high diffusivities is beneficial for avoiding impurity accumulation in the planned long pulse operations of W7-X, especially for the high $Z$ materials, including tungsten.