Modelling of tungsten transport in the presence of ICRH and NTMs in JET

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Tungsten has good properties as a plasma facing component due to its high heat tolerance, low erosion rate, and low hydrogen retention. Tungsten will be used in ITER, is a candidate material for a fusion reactor, and is presently used in the ITER-like wall at JET. Since tungsten and other high-Z ions radiate strongly, their concentration in a fusion plasma must be controlled, and central accumulation must be avoided to ensure stable operation conditions and good performance. For ITER scenario planning, it is therefore important to have an understanding of impurity transport underpinned by comprehensive theoretical models. As a prerequisite for reliable predictions, it is important that these models be validated against existing experiments.

The treatment of heavy impurities is complicated by their large mass and charge, which imply a strong response to plasma rotation or any small background electrostatic field in the plasma, such as that generated by anisotropic external heating. These forces lead to strong poloidal asymmetries of impurity density, which have recently been added to numerical tools describing both neoclassical (NEO) and turbulent (GKW) transport. These tools have identified neoclassical transport enhanced by centrifugal effects as the dominant mechanism responsible for central tungsten accumulation and non-accumulation.

In this work, validation of these tools is extended by their application of two new categories of JET plasmas (described below), and predicted two-dimensional impurity density distributions are compared with experimental tungsten densities interpreted from soft X-ray diagnostics. First, we examine baseline H-modes in which central tungsten accumulation is mitigated by central ICRH heating. In the ICRH discharges, strong minority heating enhances neoclassical impurity temperature screening, and an anisotropy-induced HFS tungsten localization reduces neoclassical impurity diffusivity, leading to centrally hollow profiles. Second, we examine a hybrid H-mode in which an accumulation of tungsten appears correlated with the appearance of a 3/2 NTM mode. Here, we examine if changes in neoclassical and turbulent transport due to the profile flattening of the island are sufficient to explain the observed correlation, or if additional mechanisms are required.

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