Transport analysis of Tungsten and Beryllium in JET Hybrid Plasmas with the ITER-like wall

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The development of standard H-mode and Hybrid scenarios in JET after installation of the ITER-like wall has indicated the need of understanding and eventually controlling the phenomenon of heavy impurity accumulation that hinders the attainment of good confinement for long durations [1]. Hybrid plasmas seem to behave better than H-modes in this respect, since Hₙ₈ factors ~1.1-1.3 can be achieved for the initial ~2 s of the discharge [2]. However also in Hybrids W accumulation soon occurs, compromising the performance. This paper aims at studying the time evolution of W and Be transport in a typical well diagnosed low δ Hybrid discharge, in order to understand the physics mechanisms leading from the initial, impurity-free, mild MHD, good confinement phase to the deteriorated phase with impurity accumulation and strong MHD activity. The W and Be density profiles have been simulated using the 1D JETTO/SANCO transport code in which plasma profiles are fixed from experiment and impurity profiles are predicted using neoclassical transport from NCLASS and an empirical anomalous diffusivity adjusted to reproduce quantitatively Zeff, radiated power and SXR emission tomographies, and VUV and CX spectroscopy. It is found that a key player in the onset of W accumulation is the density peaking in the inner plasma region. In the initial phase, the density profile is flat and the T₁ profile very peaked, leading to outward neoclassical convection, which keeps most of W in the outer part of the plasma. Centrifugal effects on the hollow W profiles are evident, introducing a marked poloidal asymmetry of the radiation patterns. The 1D simulations can be matched to 2D data by applying analytical expressions such as described in [3]. Poloidally averaged concentrations nₚ/nₑ~2×10⁻⁵ and nₚ/e⁻~0.02 are inferred. Later on, the electron density gradient increases, turning the neoclassical W convection into inward. Its effect can become suddenly dramatic in association with a MHD crash, which flattens the hollow W profile bringing W to the inner region where neoclassical transport dominates over the turbulent one. Then W accumulation occurs, the radiation and SXR profiles peak in the center, MHD is strengthened, the ion temperature and rotation gradients decrease and H98 drifts below 1. The interplay between these various effects is under study. This empirical transport analysis is supported with mutual feedback by first-principle 2D transport simulations including centrifugal effects made using NEO and the gyro-kinetic code GKW. These studies are reported separately in [4].

[4] C. Angioni et al., Neoclassical and turbulent transport of W in toroidally rotating JET plasmas, this conference

*See appendix of F. Romanelli et al., Proc. of the 24th IAEA Fusion Energy Conf., 2012, San Diego, USA