Impurity induced divertor plasma oscillations

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The fusion energy production goals for next generation tokamaks, such as ITER, necessitate significantly increased power flux from core plasma to scrape-off-layer (SOL) and divertor. This would cause the heat load to the divertor target plates to exceed damage limits for available plate materials, e.g. tungsten, leading to impurity production, in particular, in form of dust. The currently envisaged heat flux mitigation techniques also employ controlled seeding of divertor plasma with impurities, e.g. nitrogen, to achieve radiative power dissipation and partially detached plasma conditions.

In this work we report on impurity induced self-sustained plasma oscillations that are found using computer modeling with plasma transport codes DUSTT/UEDGE and SOLPS of ITER-like divertor plasmas seeded with tungsten dust or nitrogen. The oscillations produced in the high- and low-Z impurity seeding cases are characterized by significantly different divertor plasma and impurity dynamics. Two models of the oscillations are proposed based on impurity radiation – plasma condensation instability mechanism accompanied by: i) parallel impurity ion transport due to plasma thermal force in SOL, and ii) cross-field impurity neutral transport due to radial pressure gradient in the vicinity of the divertor plates. The both mechanisms are associated with regular macroscopic plasma-impurity dynamics, which differs the oscillations from intermittent plasma turbulence events. The implications of the plasma oscillations on divertor operation, in particular on target plate heat load, in ITER scale tokamaks are discussed.