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Mitigation of edge localised modes with magnetic perturbations in ASDEX Upgrade

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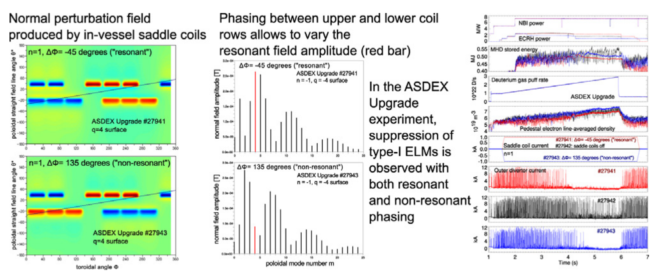
HIGHLIGHTS

- ELM mitigation is observed with $n=1$, $n=2$ and $n=4$ perturbations.
- For $n=1$ and $n=2$, both field aligned (resonant) and non-aligned (non-resonant) perturbations are efficient.
- Main access criteria for ELM mitigation is a minimum edge density Greenwald fraction of 0.6 ($n=1$) and 0.65 ($n=2$).

GRAPHICAL ABSTRACT



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ABSTRACT

The first stage of a significant enhancement of the ASDEX Upgrade experiment with in-vessel coils for non-axisymmetric magnetic perturbations is now operational. First experiments have shown that ELM mitigation can be achieved using various perturbation field configurations with toroidal mode numbers $n=1$, 2, 4. The main access criteria is the plasma edge pedestal density to exceed a threshold, which takes the lowest value of about 60% of the Greenwald density for resonant $|n|=1$ perturbations. In H-mode plasmas, mode locking or error field-induced magnetic islands are generally not observed. Due to the low local shear of the plasma magnetic field in the vicinity of the perturbation coils around the outboard midplane, the magnetic perturbation is resonant simultaneously on several rational surfaces. It is hypothesised that the existence of image currents on these surfaces ensures good shielding of the error field in the confined plasma.

1. Introduction

The ASDEX Upgrade (AUG) experiment is currently being enhanced with a set of in-vessel saddle coils and supporting tools for MHD control [1]. The first stage of this project, a set of 16 off-midplane coils capable of producing a small non-axisymmetric perturbation field (radial field $B_r \sim 10^{-3} B_t$), has been implemented as described in Refs. [2,3]. For the 2011 experimental campaign, a first subset of eight coils (four above and four below the midplane) have been available. The full set of eight coils above and eight coils below the midplane has become operational for the 2012 campaign. So far, experiments have been conducted with DC currents provided by pre-existing grid-commutated thyristor bridge converters (two independent four quadrant circuits). A complementary modular and economical AC-capable power supply is in preparation [4].

In view of ITER needs, physics experiments so far have mainly targeted ELM mitigation [5,6], effects on high-confinement mode (H-mode) transport barrier [7,8], 3D effects on equilibrium and divertor magnetic configuration [9,10], H-mode access threshold [11], scrape-off layer properties [12], and fast particle transport

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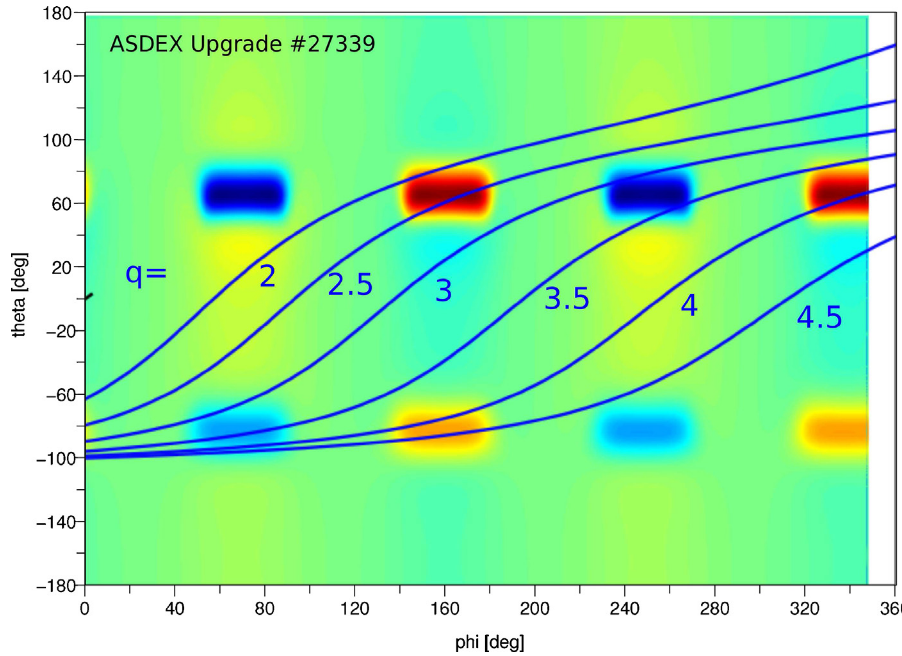

Fig. 1. Normal field on the unfolded nominal $q = -2$ surface (colour contours), overplotted with field lines at different rational surfaces. (For interpretation of references to colour in the text, the reader is referred to the web version of this article.)

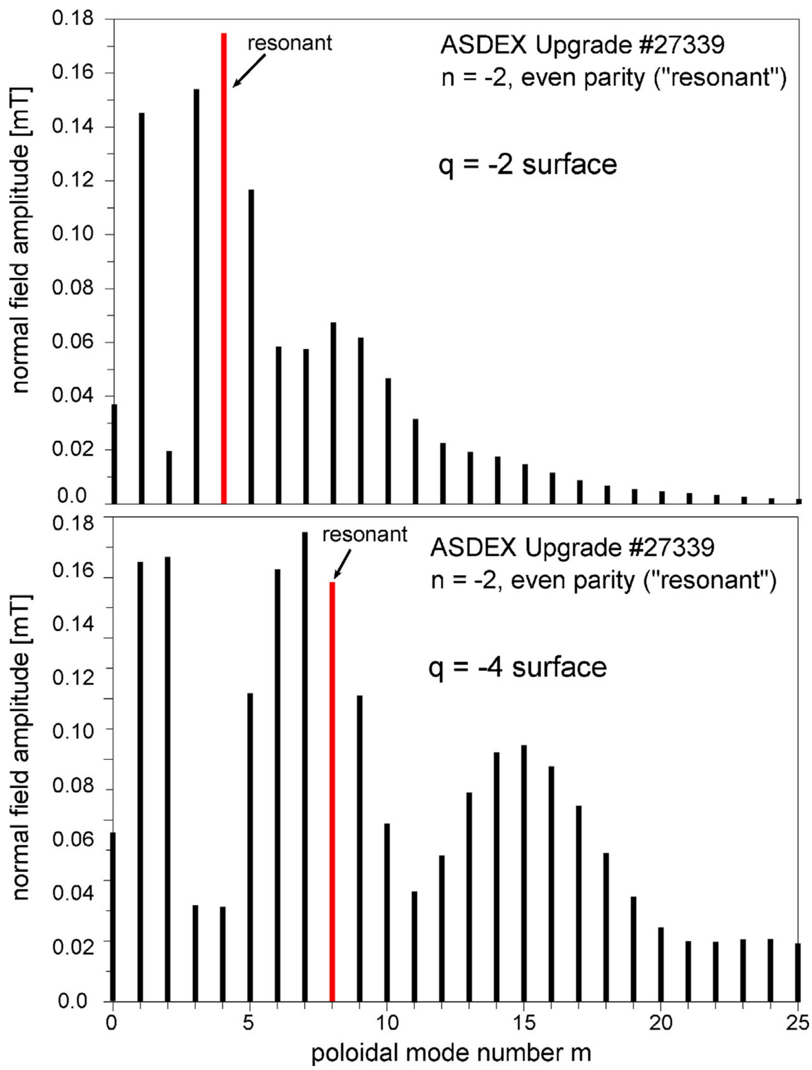

Fig. 2. Poloidal mode number spectrum $B_n(m)$ [T] for $n = -2$ magnetic perturbation, calculated for the $q = -2$ (top) and $q = -4$ (bottom) surfaces. (For interpretation of references to colour in the text, the reader is referred to the web version of this article.)