FIRST RESULTS OF EHO-LIKE FLUCTUATIONS STUDIES AT THE SPHERICAL TOKAMAK GLOBUS-M2

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1. INTRODUCTION

The high-confinement mode (H-mode) is generally characterised by the development of edge-localised modes (ELMs) that are responsible for the periodic release of heat and particles to the plasma edge which can lead to erosion and damage of plasma facing components [1]. ELM control, mitigation or elimination is thus seen as an important issue for fusion devices. One potential solution to this problem is the quiescent H-mode which is accompanied by edge harmonic oscillations (EHOs) [2] EHOs have been observed in the form of coherent, narrow electromagnetic modes with multiple harmonics existing in edge plasma on various tokamaks [3-5]. EHO-like oscillations have been recently observed on the compact spherical tokamak Globus-M2 [6].

2. EHO-LIKE FLUCTUATIONS ON GLOBUS-M2

EHO-like oscillations have primarily been observed in weakly shaped discharges (triangularity $\delta < 0.2$) with neutral beam injection (NBI) heating and large safety factor ($q_{95} <= 6$). They were detected in the form of coherent fluctuations on various diagnostics: a clear peak at the 8 kHz frequency can be observed in the spectra of the D_α signal, fluctuations of magnetic probe (MP) signals amplitude $\tilde{B}_{MP}$, average electron density measured using interferometry n_e^{int}, perpendicular rotation velocity V_{perp} and backscattered power P_{DBS} measured using Doppler backscattering (DBS) at R = 0.59 m for discharge #44335 as shown in Fig.1a. The oscillations were primarily detected on edge diagnostics, such as Langmuir probes, and DBS confirmed that the mode developed at the plasma edge at radii 0.56-0.61 m. The magnetic probe array identified the toroidal mode numbers of the EHO to be a superposition of n = 1 and 3.

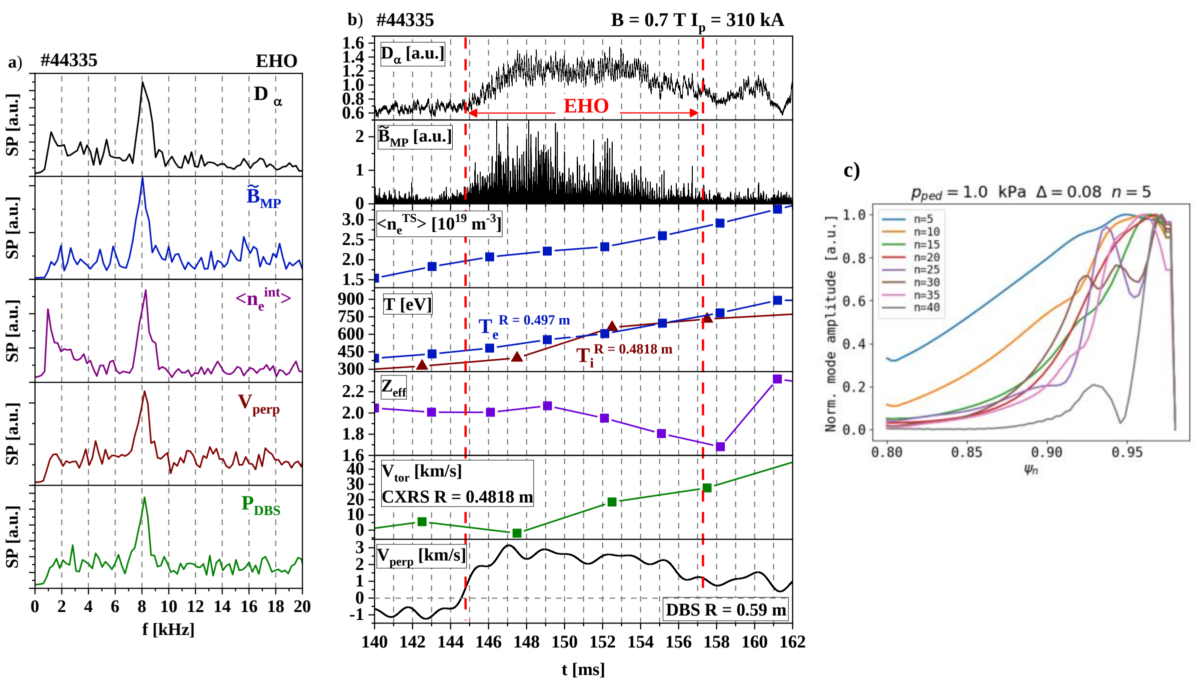

Figure 1. a) spectra of diagnostics signals (from top to bottom) D_α signal, fluctuations of MP signals amplitude $\tilde{B}_{MP}$, average electron density measured using interferometry n_e^{int}, perpendicular rotation velocity V_{perp} and DBS backscattered power P_{DBS} at R = 0.59 m exhibit peaks at 8 kHz; b) temporal evolution of (from top to bottom) D_α signal, $\tilde{B}_{MP}$, average electron density measured using TS diagnostics n_e^{TS}, ion T_i (measured using CXRS) and electron T_e (measured using TS) temperatures, effective ion charge Z_{eff}, toroidal rotation velocity V_{tor} and V_{perp}. The start and end of the EHO-like oscillations is indicated by vertical red lines; c) The poloidal mode structure for the marginally stable simulation case with the dominant toroidal mode number n=5 at pedestal height p_{ped} = 1.0 kPa, pedestal width Δ=0.08, and triangularity δ=0.2 for discharge #44335

The dynamics of the plasma parameters during the EHO was also investigated with their temporal evolution presented in Fig.1b. During the time of its existence (see EHO-like oscillations on the D_α signal and $\tilde{B}_{MP}$) there is an increase of the average electron density n_e^{TS} and electron temperature T_e measured using Thomson scattering (TS) diagnostics, however the rate of this growth seems to slow down. The ion temperature T_i obtained using charge exchange recombination spectroscopy (CXRS) seems to grow more rapidly after the start of the EHO. There is also a steady decrease of the effective ion charge Z_{eff} with its gradual increase after the mode's disappearance at 157.8 ms which serves as an indicator of changes in the impurity content during the EHO. CXRS was also able to detect an increase on the toroidal rotation velocity V_{tor} as well as the toroidal rotational shear. The perpendicular rotation velocity V_{perp} measured using DBS at R = 0.59 cm changes dramatically after the start of the EHO-like oscillations going from negative with values of about 1 km/s to positive reaching up to 3 km/s. Multi-frequency DBS allowed to investigate the changes in profiles of the V_{perp} and the corresponding radial electric field.

The pedestal conditions during the EHO phase of the Globus-M2 discharge #44335 were close to the peeling-ballooning stability limit in the linear 3-field MHD simulations that used the BOUT++ [7] code. The most unstable mode had low toroidal numbers (n=5). The nonlinear calculations demonstrated the poloidal mode structure span significantly inside the plasma (Fig. 1c), holding up to experimental observation of EHO-like oscillations inside the plasma confinement region.

In experiments on Globus-M2 several types of scenarios of the EHO were observed. In some cases, the fluctuations exist for most of the discharge, despite the development of other modes such as sawteeth, however under other conditions the EHO would disappear and be followed by a transition to an ELMy H-mode.

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