Analysis of edge harmonic oscillations observed during operation of the National Spherical Tokamak Experiment

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Edge harmonic oscillations (EHOs) have been observed during operation of the National Spherical Tokamak Experiment (NSTX) in which no edge localized modes have appeared. This paper will utilize beam emission spectroscopy and Mirnov coil diagnostic data to analyze the frequency, mode number, and amplitude of EHOs observed in NSTX. Additionally, charge exchange recombination spectroscopy and multiple point Thomson scattering diagnostics will be used to analyze the plasma pedestal region, while outputs from a magnetohydrodynamics equilibrium fitting code will be used to characterize the global plasma during the occurrence of an EHO. This extensive analysis highlighted several relationships between EHOs and various plasma parameters. Notable data trends included access to higher toroidal mode numbers at lower electron collisionality, lower toroidal rotation speed, and within narrows bands of electron pressure and density pedestal heights and gradients. Additionally, larger amplitude EHOs were preferentially detected within a range of toroidal rotation speed and at larger electron density and pressure pedestal gradients and heights. Finally, correlations between high confinement times and reduced EHO activity as well as reduced frequency gap between adjacent EHOs were also found.
Analysis of Edge Harmonic Oscillations Observed in NSTX

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INTRODUCTION

Edge harmonic oscillations (EHOs) have been a topic of recent focus in an attempt to mitigate the harmful effects that edge localized modes (ELMs) can create during the operation of fusion devices. Currently, there is very little understanding of the underlying physics of EHOs, but they have appeared in fusion devices operating in quiescent H (OH) mode.\textsuperscript{1} This regime is currently being heavily explored because of the ability to operate devices without ELMs, but instead with EHOs. In some devices, such as DIII-D, EHOs have been seen to saturate at current densities below the threshold for ELMs and thus allowing for ELM-free operation.\textsuperscript{7} This is believed to be a result of enhanced particle transport. More recently, EHOs have been observed in ELM-free operation of the National Spherical Torus Experiment (NSTX). However, initial studies suggest EHOs do not seem to saturate at current densities below the threshold for ELMs and instead with EHOs. In some devices, such as DIII-D, EHOs have been explored because of the ability to operate devices without ELMs, but they have appeared in fusion devices operating in various tokamaks.\textsuperscript{9}

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DATA ANALYSIS METHODOLOGY

Objective

• Create MATLAB functions to manipulate and data from a magnetohydrodynamics equilibrium fitting code (EFIT) along with beam emission spectroscopy (BES), Mirnov coils, charge exchange recombination spectroscopy (CHERS), and multiple Thomson scattering (MPTS) diagnostics on NSTX.

• Identify and analyze EHOs in NSTX and gather plasma characteristics during EHO occurrences.

• Identify trends between EHO characteristics and plasma characteristics.

EXPERIMENTAL METHODS

BES

• Collect Doppler-shifted D\textsubscript{3} emissions (n=1\textrightarrow{}2) from neutral beam and filter from thermal D\textsubscript{3} emissions.\textsuperscript{3}

• Poloidal array images from core to scrape-off layer.\textsuperscript{2}

• Mirnov Coils

• Measures poloidal magnetic field at locations around the torus.\textsuperscript{4}

• 10 of 16 channels were used.

CHERS

• Collect N\textsubscript{2}(p,\textalpha)7 emission from neutral beam interactions.\textsuperscript{9}

• Doppler-shifted emission light used to obtain quantities such as electron density and temperature.

MPTS

• Collect light scattered from laser beam in plasma.\textsuperscript{10}

• Maps frequency of scattered light at position of emitted light in plasma.\textsuperscript{5}

• BES channel layouts for R140 views on the center plane of the neutral beam with typical flux surfaces.\textsuperscript{6}

• ECHERS rotation speed data to the top of the pressure pedestal and average over each time of interest.

• Piecewise linear-

EHO TOROIDAL MODE NUMBER RESULTS

1) Calculates frequency spectrum of shot #141055.

2) Horizontal lines of high auto correlation - with plasma and pedestal parameters, especially amplitude, frequency and toroidal mode number – with plasma and pedestal parameters, especially amplitude, frequency and toroidal mode number of EHOs, but they have appeared in fusion devices operating in various tokamaks.\textsuperscript{9}

3) Maps frequency of scattered light at position of emitted light in plasma.\textsuperscript{5}

4) BES channel layouts for R140 views on the center plane of the neutral beam with typical flux surfaces.\textsuperscript{6}

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6) REFERENCES


