Observation of Compressional Alfven Eigenmodes in a Conventional Tokamak W.W. Heidbrink (wwheidbr@uci.edu), M.S. Kim University of California, Irvine E.D. Fredrickson, N.N. Gorelenkov Princeton Plasma Physics Laboratory T. Rhodes, G. Wang University of California, Los Angeles M.A. VanZeeland

ORISE

Fast-ion instabilities with frequencies somewhat below the ion cyclotron frequency occur frequently in spherical tokamaks such as the National Spherical Torus Experiment (NSTX). NSTX and the DIII-D tokamak are nearly ideal for fast-ion similarity experiments, having similar neutral beams, fast-ion to Alfven speed v_f / v_A , fast-ion pressure, and shape of the plasma, but with a factor of two difference in the major radius. When DIII-D is operated at low field (0.6 T), compressional Alfven eigenmode (CAE) instabilities appear that closely resemble the NSTX instabilities. In particular, the mode frequencies, polarization, and beam-energy threshold are nearly identical to NSTX. CAE in high-field discharges and emission at cyclotron harmonics are also observed. As on NSTX, the basic stability properties are consistent with the idea that the instability is driven by anisotropy in the fast-ion velocity distribution and is damped predominately by Landau damping of electrons. The results suggest that these modes could be unstable in ITER.

Instabilities with frequencies $f=0.4-1.1 f_{ci}$ are observed in most beam-heated discharges in the National Spherical Torus Experiment (NSTX). (f_{ci} is the ion cyclotron frequency.) Similar instabilities are also common in the Mega Ampere Spherical Tokamak (MAST). NSTX studies of the sub-cyclotron emission indicate that the instabilities are usually compressional Alfven eigenmodes (CAE), although some of the modes are probably global Alfven eigenmodes [1]. The phenomenology of CAEs was studied extensively in NSTX [2]. Although emission at harmonics of the ion cyclotron frequency is often observed in conventional tokamaks, emission at ~0.6 f_{ci} has never been reported. This raises the question: is sub-cyclotron emission peculiar to spherical tokamaks? Or can it occur in large-aspect ratio devices such as ITER?

Recent experiments in DIII-D show that CAE are also common in conventional tokamaks when the fast-ion speed exceeds the Alfven speed. Figure 1 shows an example from a 0.6 T discharge with modulated injection of a 80 keV deuterium neutral beam. CAE activity is also detected in some full-field (2 T) discharges, although it is less common. Phenomenologically, the instabilities in DIII-D are very similar to NSTX. The data are in qualitative agreement with the idea that the primary damping mechanism is parallel electron Landau damping, while the principal driving term is a bump in the fast-ion distribution function caused by finite orbit effects.



Figure 1. Magnetics signal and spectra in a low-field DIII-D discharge. The beam power is also shown.

A full-length paper on these observations was submitted to Nuclear Fusion in August 2005 [3]. Recent work is concentrating on the poloidal and radial structure of the modes. The origin of the frequency splitting is also under investigation.

References

[1] GORELENKOV, N.N., et al., Nucl. Fusion 43 (2003) 228.

[2] FREDRICKSON, E.D., et al., Phys. Plasmas 11 (2004) 3653.

[3] HEIDBRINK, W.W., et al., "Observation of Compressional Alfven Eigenmodes in a Conventional Tokamak," submitted to Nucl. Fusion (2005).