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April 2017

Microwave Heating Can Control Alfvén Waves in Fusion Plasmas

Microwave heating can significantly alter the spectrum of Alfvén waves in fusion plasmas to potentially avoid losses of energetic particles.

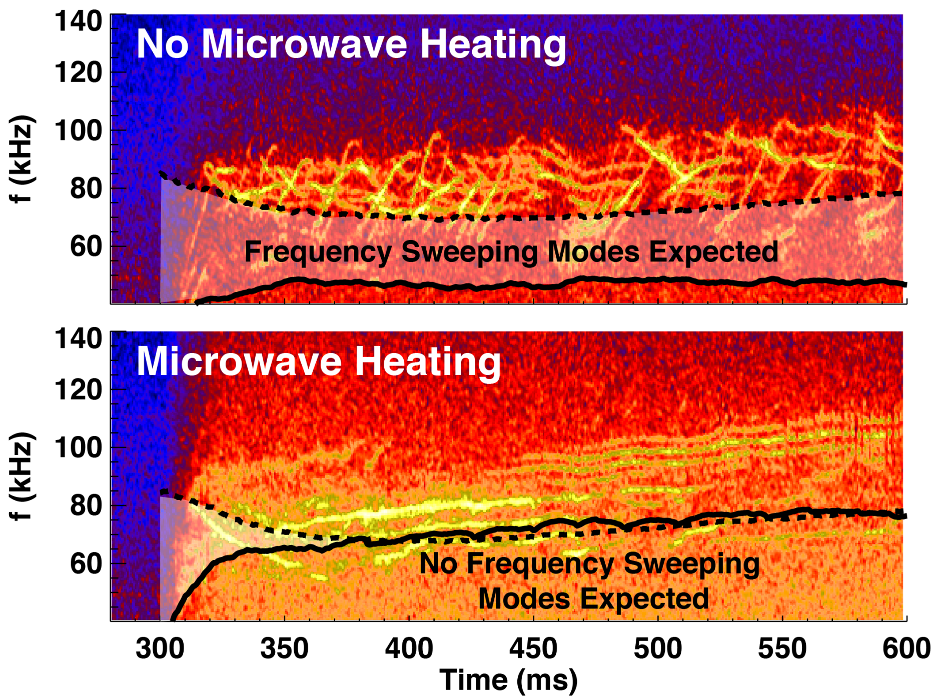

Image courtesy of M. Van Zeeland
Spectrograms showing the change in wave activity with and without microwave heating. With no heating (top), upward frequency sweeping RSAEs are observed. With heating near the wave location (bottom), no RSAEs are expected or observed. The black curves indicate that the electron heating leads to closure of a theoretically predicted window (gray shading) in which these modes exist.

The Science

Microwave beams are deposited near the location of reversed shear Alfvén eigenmodes (RSAEs), a type of wave in fusion plasmas that can cause losses of energetic particles, and are found to modify the wave activity significantly - in some cases completely removing the modes. This effect is a result of microwave heating changes to the local plasma temperature distribution that increase the natural mode frequency to a point where it no longer exists.

The Impact

Alfvén waves can cause redistribution or loss of the fast alphas as well as injected neutral beam ions that are needed to heat fusion devices. If these waves are allowed to grow unabated, the resultant fast ion transport can reduce performance and potentially damage vessel components. These results address one of the few known tools (Electron Cyclotron Heating) capable of targeting and altering Alfvén waves in fusion plasmas, as well as strengthen our basic understanding of the physics of the modes themselves.

Summary

Localized electron heating by microwaves has been shown to be an effective tool for modifying Alfvén eigenmode activity in DIII-D. Due to the fact that localized electron heating can impact essentially all aspects of these waves, including mode drive, damping, and the actual eigenmode structure, a satisfactory explanation for this effect has been elusive and formed the basis of a joint experiment involving researchers from several devices worldwide. It is found here that modification of the so-called RSAEs occurs through finite pressure effects via the microwave impact on the local electron temperature. The change in temperature gradient is the dominant factor in altering the wave spectrum in these experiments. The impact on frequency sweeping RSAEs is captured in a large collection of discharges by a simple model which is based on constraining the RSAE frequency sweep to be in a frequency range (or "window") dependent on the plasma pressure profile and magnetic topology. This new understanding, coupled with the fact that discharges with reduced RSAE activity also have improved fast ion confinement, offers worthwhile and intriguing possibilities for Alfvén eigenmode control applications.

Contact

Michael Van Zeeland
General Atomics
vanzeeland@fusion.gat.com

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Publications

M.A. Van Zeeland, W.W. Heidbrink , S.E. Sharapov , D. Spong , A. Cappa, et al. "Electron cyclotron heating can drastically alter reversed shear Alfvén eigenmode activity in DIII-D through finite pressure effects", *Nucl. Fusion* **56**, 112007 (2016). doi:10.1088/0029-5515/56/11/112007

Related Links

https://fusion.gat.com/global/DIII-D

Highlight Categories

Program: FES
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