ANTENNA OPTIMIZATION FOR SHEAR ALFVÉN WAVE HEATING

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Antenna Optimization for Shear Alfvén Wave Heating.* D. KORTBAWI, S.Y. ZHU, T. CASAVANT, J.C. SPROTT, and S.C. PRAGER, University of Wisconsin-Madison--Two new antennas are now installed in the Tokapole II Tokamak. They are Faraday shielded and can be rotated a full 360° to launch waves of any polarization. They are located 180° apart poloidally. They have been operated at low power in a very limited range of plasma parameters. Preliminary results are that these antennas do not couple very strongly to the plasma. Radiation resistance varies from 241 mΩ to nearly the vacuum value of 94 mΩ as the antennas are rotated from B perpendicular to B₀ to B parallel to B₀. The reactive component is very small in all cases. The loading observed is the same whether one or both antennas are operated. Further results, covering a broad range of plasma parameters, will be presented.

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TOKAPOLE II PARAMETERS

- FOUR NODE POLOIDAL DIVERTOR
- MICROWAVE PREIONIZATION
- MAJOR RADIUS 50 cm
- MINOR RADIUS 6-10 cm
- TOROIDAL FIELD 4.5 kG
- PLASMA CURRENT ~30 kA
- LINE AVERAGED DENSITY 5*10^{12} cm^{-2}
- ELECTRON TEMPERATURE ~100 eV
- ION TEMPERATURE ~20 eV
- DISCHARGE LENGTH ~3-10 msec
- BASE VACUUM 6*10^{-7} Torr
TYPE I ANTENNAS

Maximum rotation ± 45°
wrt the toroidal axis
Radial insertion range 6cm

Two antennas of this type have been in use for some time.
TYPE II ANTENNAS

Rotation range $360^\circ$
Radial insertion range 6cm

Two antennas of this type have recently been installed and operated at low power. Two more are to be constructed.
OF ALFVEN WAVE ANTENNAS

FOUR ANTENNAS WILL BE USED.
TYPE I ANTENNAS WERE DOMINATED BY PARASITIC LOADING.

The loading seen was quite insensitive to plasma parameters and peaked when the antenna currents were ~ parallel to the equilibrium fields. Most of the energy was dissipated in the surface.
Angle of Antenna Currents w.r.t. $B_1$
Magnetic probe signals show a resonant spatial structure and polarization consistent with the Shear Alfvén wave. The magnitude of the observed signal was however relatively independent of antenna loading.
PROBE SIGNALS SHOW A SPATIAL RESONANCE.

Angle of antenna currents
w.r. to toroidal axis

- $\theta = 0^\circ$
- $+40^\circ$
- $-40^\circ$

MINOR RADIUS (cm)
The type II antennas show a similar dependence on angle when nearly toroidal. However when the currents are perpendicular to the equilibrium fields the loading is significantly enhanced.
Loading shows a significant angular dependence
Radiation resistance is a sharp function of antenna angle.
(When antenna current is nearly poloidal)
Rotating antenna through 180 degrees strongly affects loading.
LOADING IS ESSENTIALLY INDEPENDENT
OF ANTENNA PHASING.
Reversing the direction of the toroidal field wrt the plasma current does not simply shift the peak to the other side of 90°.
LOADING IS SIGNIFICANTLY DIFFERENT ON THE 2 ANTENNAS.

Which one is more heavily loaded depends on the operating conditions.
Upper antenna

RADIATION RESISTANCE (ohms)

TIME (msec)

$B_t$ forward 80°

$B_t$ reversed 280°
Lower antenna

RADIATION RESISTANCE (ohms)

TIME (msec)

$B_t$ forward 85°

$B_t$ reversed 280°
THIS LOADING IS ALSO FAIRLY SENSITIVE TO PLASMA PARAMETERS.
RADIATION RESISTANCE (ohms)
ARBITRARY UNITS

Central chord SXR

Shot # R-200
RADIATION RESISTANCE (ohms)
RADIATION RESISTANCE (ohms)

Lower antenna
Shot A 20002
CONCLUSIONS

Loading increases significantly when antenna currents are nearly perpendicular to the equilibrium field.

This loading has some characteristics which are difficult to explain.

It is fairly sensitive to plasma parameters and is quite reproducible.
IMMEDIATE FUTURE PLANS

Start production of 2 more antennas.

Use magnetic probes to see if enhanced loading gives increased signal.

Move one of the type II antennas to a different toroidal location to see if toroidal mode structure affects loading.