Pulsed Alfvén Wave Experiments in a Helicon Plasma Source

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Objectives of this Work

Experiments to test a model for ion heating in the fast solar wind based on ion cyclotron damping of MHD turbulence driven by nonlinearly interacting, low frequency Alfvén waves [Matthaeus et. al., 1999], are being conducted in the West Virginia University HELIX (Hot hELIcon eXperiment) device in argon and helium plasmas. It is argued that counter-propagating waves arise from reflection of the waves off of a gradient in the Alfvén speed. The HELIX device has a similar speed gradient profile to that found in the solar corona: a short region of high Alfvén speed followed by an expansion region of lower Alfvén speed. Here we present measurements of attempts to launch Alfvén waves via short-pulsed amplitude modulation of the steady-state RF drive of the plasma-creating ($m = 1$) helicon antenna, with the goal of being able to assess the reflection of the waves in the time domain.
The HELIX Device

Area in next slide

Plasma Physics Laboratory
The diagnostics used were a pair of probes with tri-axial (radial, azimuthal, axial) magnetic pickup coils, amplified via a set of high-frequency differential amplifiers, and digitizable at up to 100 MHz. For the work discussed in this poster, 25 kHz was used.
Control Signal and Modulation Configuration Setup

- **DAQ computer** (LabWindows on Windows XP)
  - GPIB
  - TTL
  - Demodulator
  - Fiber Optic
- **TTL Modulator**
- **VI Controls**
- **Wavetek 80** (RF Source)
  - OUTPUT
- **HP 33120A** (AM Source)
  - EXT TRIG
  - Analog (1V)
- **Matching Network**
- **Joerger VTR 10012 Digitizer**
  - EXT TRIG
  - USER 1
  - USER 2
- **ENI A1000 Power Amplifier**
- **NI-BNC-2090 USER 2**
- **NI-DAQ**
- **EXT VXI**
- **VXI**
**Operation**

- For the pulsed AM scenario discussed here, the HELIX main RF source ran continuously. The data acquisition system was set up to take data in a fixed window based on a periodic external pulse, and the function generator that provided the AM was triggered 500 microseconds later. This allowed multiple pulses to be averaged with the AM phase fixed in time.
- The AM was set up to impose a ~20% modulation on the RF source.
- 25 averages were used for the data analyzed in this paper.

**Cartoon of Timing Scenario**
Preliminary Results

• Following the lead of Y. Amagishi [PRL 57 no. 22, 2807 (1986)], we look at the azimuthal pickup coil signals.

• For all cases:
  RF power: 650 W
  RF frequency: 9.5 MHz
500 Gauss central magnetic field, helium discharges, low density

- The azimuthal pickup coil signals are sinusoidal below, near, and above the ion cyclotron frequency.

- No obvious phase delay between the upstream and downstream probe signals can be discerned.
750 Gauss central magnetic field, helium discharges,

- In contrast to the low-density case, a time delay between the upstream and downstream probes is apparent.
- The signals are manifestly sinusoidal below the ion cyclotron frequency.
750 Gauss central magnetic field, helium discharges, higher density

- Near and above the ion cyclotron frequency the signals are more complex.
- Possibly indicative of a reflection at the Alfvén speed gradient further downstream.
- Reflection could result from modification of $k_{||}$ by the cyclotron resonance.

- Non-sinusoidal signals are not a result of parametric decay as power spectra show no evidence of it.
Future Work

- Use a higher sampling rate.
- Cross-check against CW experiment results
- Run at same parameters
- Different probe setups
- More probes
- Further from RF source
- Include additional diagnostics.
Summary:

• A hardware setup for doing pulsed amplitude modulation of the HELIX RF system has been implemented.
  • Important new feature: triggering of the data acquisition system at a fixed time with respect to the AM pulse.
• There is a density dependence in the pickup coil signals.
  • Substantial time delay between upstream probes only at high density.
  • Indications of a possible wave reflection can be seen at high density.
Links

• This poster in its original format
  http://ulysses.phys.wvu.edu/~plasma/APSHansen07.pdf

• Other WVU Helicon Source Group posters
  http://ulysses.phys.wvu.edu/~plasma/posterlinks.html