Stimulated Excitation of Thermal Waves in Magnetized Plasmas and Application to Thermal Conductivity Measurement

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Results are presented from basic heat transport experiments using a magnetized electron temperature filament that behaves as a thermal resonator. Experiments are performed in the Large Plasma Device at the Basic Plasma Science Facility (BaPSF), University of California, Los Angeles. A CeB_6 cathode injects low energy electrons along a magnetic field into the center of a pre-existing plasma, forming a hot electron filament embedded in a colder plasma. Previous experiments observed spontaneous thermal (diffusion) waves and demonstrated the frequency of the temperature oscillations matched the conditions for a quarter-wave thermal resonator [1].

In new experiments, a series of low amplitude, sinusoidal perturbations are added to the cathode discharge bias, thus creating an oscillating heat source capable of driving thermal waves [2]. Langmuir probe measurements demonstrate driven thermal oscillations and allow for the determination of the amplitude and parallel phase velocity of the thermal waves over a range of driver frequencies. The results demonstrate the presence of a thermal resonance and are used to verify the parallel and perpendicular thermal wave dispersion relations based on classical transport theory. A nonlinear transport code is used to verify the analysis procedure. It is also shown that a heat equation in the form of a reaction-diffusion equation can be derived with a solution that closely matches the observed thermal resonance. This technique provides a measure of the density normalized thermal conductivity, independent of the electron temperature.

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References

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