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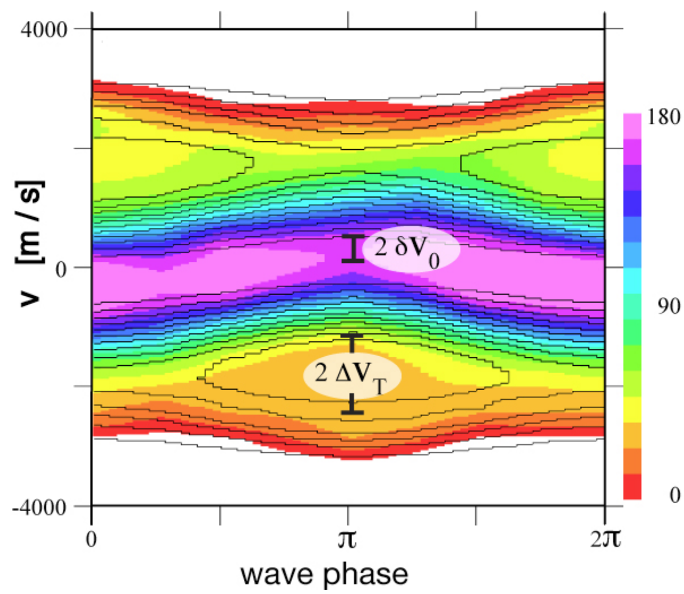
Teaching Plasma a New Tune

Scientists make the first detailed measurements that demonstrate the existence of new acoustic wave in plasma.

DALLAS, Texas—Recent experiments in the non-neutral plasma group of the University of California, San Diego, have demonstrated the existence of a new kind of plasma wave, the Electron Acoustic Wave (EAW).

For most of the last 50 years, physicists expected that EAWs, if they existed, would be heavily damped and insignificant. But in the 1990's new theories emerged that suggested otherwise. These were, for the most part, ignored – until now, when we have observed these EAW plasma waves directly.



These new waves are acoustic, like the music of an orchestra. When driven to large amplitudes, the waves "train" the plasma so that it resonates at the driver frequency even after the driver is turned off, for any frequency chosen by the experimentalist. Put another way, it's as if a grandfather clock could be taught to speed up by changing the length of its pendulum.

These variable frequency waves may be cousins of KEEN waves observed in numerical simulations and relevant in high energy density plasma experiments. These plasma waves have also been observed in laser-produced plasma on the Trident laser at Los Alamos National Laboratory.

Our group has made the first detailed measurements showing the nonlinear interaction of the plasma with the wave. To perform this work we chose one of the simplest plasmas, trapped non-neutral magnesium ion plasma. These plasmas are very well controlled and can be confined for weeks. Sophisticated lasers allow us to observe the intimate interaction between waves and plasma particles. As shown in the figure above, the waves modify particle trajectories in just the manner required to allow these waves to propagate without damping.

The figure represents the measured particle velocity as a function of the wave phase. The colors represent the number of particles with a given velocity. The slow particles (pink) are oscillating with the wave, like a buoy oscillating up and down on an ocean swell. The particles trapped by the wave (yellow-orange) are like a surfer riding on a wave. The top and bottom portions of the graph represent particles that are moving too fast to be trapped by the wave like a jet-ski powering through the surf.

Such detailed measurements illustrate how university-scale basic plasma physics experiments can study complex wave phenomena relevant to large-scale plasma experiments conducted in national laboratories.

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Abstract UI1.00003
Electron Acoustic Waves in Pure Ion Plasmas
Invited session UI1 Basic Plasma Experiment
3:00 PM–3:30 PM, Thursday, November 20, 2008
-Landmark A

Abstract YP6.00046
KEEN Waves, Multiple Water-Bag Models and Vlasov-Poisson vs Vlasov-Maxwell Simulations
Session YP6: Poster Session IX: Inertial Confinement Fusion and HEDP Experiments, Diagnostics and Drivers
9:45AM–12:45PM, Friday, November 21, 2008
-Marsalis A/B

Abstract PP6.00125
Diagnosing Phase Space coherent structures by the test particle method
Session PP6: Poster Session VI: Inertial Confinement and Laser-Plasma Interactions
2:00PM–5:00PM, Wednesday, November 19, 2008
- Marsalis A/B

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