Scilight

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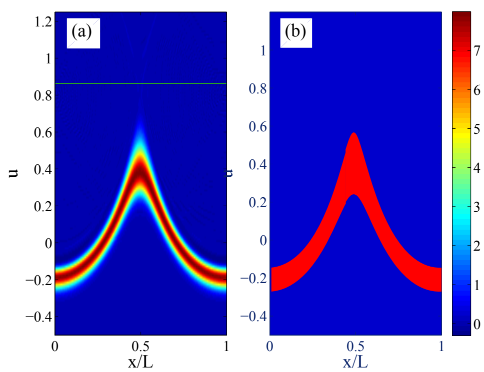
Giant nonlinear ion acoustic waves that “phase-lock” in a plasma

Rich Blaustein

Researchers demonstrate that ion acoustic waves in a plasma can be in autoresonance for significant durations and reach extreme nonlinear states.



Ion acoustic waves (IAWs) appear in many plasma contexts, including those involving lasers-plasma interactions. In laser fusion research, for example, IAWS, which are often nonlinear, are a concern because they scatter incident laser beams. Plasma physicist Lazar Friedland and numerical physicist Arkadiy Shagalov’s recently researched nonlinear IAWs. They report their findings in *Physics of Plasmas.*

Nonlinear waves can phase-lock in autoresonance. Building from their earlier research of IAWs in a weakly nonlinear context, the researchers sought to understand with both theory and simulations the nonlinear IAWs autoresonance in plasmas for extreme, large amplitude conditions. Friedland says that they initiated their theoretical analysis with the Kortewag-de-Vries assumption of weakly nonlinear waves. They then added the Whitham’s average variational principle, which offers understanding of large amplitude, extremely nonlinear waves, in this case IAWS. In total, the theory described the IAW autoresonance phenomenon.

Friedland and Shagalov thereby compared their theory to two model simulations, a water bag fluid-type model and the Vlasov-Poisson kinetic model. Both model simulations supported their predictions and demonstrated autoresonance in the system.

Friedland and Shagalov’s theory and modelling also demonstrate that eventually the phase-locking of the IAW breaks up with the occurrence of the kinetic Cherenkov resonance, in which the velocity of particles increases beyond that of the driving wave.

Friedland says he was surprised with the display of a long and adjustable autoresonance stage. He adds that for plasma physicists this research demonstrates the possibility of controlling large amplitude excitations, which would have many applications. He and Shagalov also write that the effects of ion charge and temperature in autoresonance and the details of kinetic break-up of the autoresonant IAWs are important areas for future research.

Source: “Extreme driven ion acoustic waves,” by L. Friedland and A. G. Shagalov, *Physics of Plasmas* (2017). The article can be accessed at https://doi.org/10.1063/1.4986031.