Supersonic ion-acoustic waves in a non-isothermal plasma

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The results of a study on the nonlinear motion of a non-isothermal plasma are presented, revealing properties that differ from those of classical ion-acoustic waves.

To describe the non-isothermal plasma, the Sagdeev model is employed, in which the motion of ions is governed by cold-plasma hydrodynamic equations, while hot electrons in the quasistatic field of a longitudinal wave are assumed to follow a Boltzmann distribution. It is shown that, under certain initial conditions, a non-isothermal plasma can support both nonlinear periodic waves propagating at speeds below the sound speed and supersonic periodic plasma motions.

In the small-amplitude limit, the nonlinear subsonic plasma motions exhibit dispersion characteristics identical to those of classical ion-acoustic waves; however, they differ in that their scalar potential does not alternate in sign.

The nonlinear periodic plasma motions that propagate at speeds exceeding the sound speed have no analogue in the classical theory of ion-acoustic waves. These waves are inherently nonlinear, regardless of how small their amplitude may be, and in the limit of increasing wavelength, they evolve into classical-type ion-acoustic solitons.

A characteristic feature of these waves is the transport of the ionic component of the plasma in the direction of wave propagation—a property that fundamentally distinguishes these nonlinear motions from conventional ion-acoustic waves. On this basis, it can be concluded that these nonlinear waves constitute a new class of ion-acoustic motions in a non-isothermal plasma.

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