Observation of Dust Acoustic Shocks and Stable Dust Structures in Moderately Coupled Dusty Plasma

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Laboratory plasmas are intrinsically nonequilibrium systems in which a state of ionization is maintained by an external energy source. A simple pattern that arises from an instability that is periodic in space and oscillatory in time is the travelling wave. If a controlling parameter of the system exceeds an instability threshold and pushes the system far outside of equilibrium, nonlinear waves, sustained by the balance between the drive, nonlinearity, dispersion, and dissipation, may be excited. Nonlinear waves have characteristics that are quite different from linear waves, e.g., when two nonlinear wave trains collide, one or the other may be consumed or a shock may form.

Linear and nonlinear dust acoustic waves are studied experimentally in a homogeneous unmagnetized dusty plasma [1-4]. Linear dust acoustic wave is excited by applying a variable duty cycle dc voltage through a wire shaped grid. In this regime, the phase velocity of the wave increases due to ion - dust streaming and wave suffers damping with increasing dust density.

In a dc glow discharge dusty plasma, shock formation was observed by Fortov et al.[5]. In another experiment, Heinrich et al.[6] observed self-excited dust acoustic shock waves in a dc glow discharge dusty plasma. This is very similar to the numerical solutions [7] of the fully nonlinear fluid equations for a nondispersive dust acoustic wave. Recently Sharma et al., [8] excited shock wave by perturbing a stationary dust fluid with supersonic flow of charged microparticles. Here, we report, the formation of shocks, when two insulating slits having dimensions (6 cm X 2.5 cm X 0.05 cm) are inserted in front of the grid. A pulsed dc voltage of 60 volts with 500 ms ON time and 1000 ms OFF time was applied into the grid to excite dust acoustic shocks. The self-steepening of nonlinear dust acoustic waves into a saw tooth type wave with sharp gradient in dust density was observed. The variation of shock amplitude and width from the slit position also studied.

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