Novel features of chaos in dusty plasmas

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We have investigated the phase portrait analysis, quasiperiodic, and chaotic behavior of the dust-acoustic wave (DAW) in Saturn's magnetosphere with superthermal hot and cold ions as well as Boltzmannian distributed electrons. To achieve this, the modified Kadomtsev Petviasvili (mKP) equation has been derived using the reductive perturbation method (RPM). The bifurcation theory of the planar dynamical system has been devoted to obtaining the phase portraits of the system. We have obtained the homoclinic and periodic orbits corresponding to the specific equilibrium points. Based on the homoclinic orbits of the mKP equation, we get rarefactive solitary wave structures. We have shown the solitary profile of the DAW for different plasma parameters. We have presented the solitary structure of nonlinear DAW for dust-to-ion ratio represented by p, and found that by increasing the concentration of dust, the solitary wave profile (amplitude and width) manifests an increase. We have also shown the solitary structure of the DAW for the ion-to-electron ratio represented by σ, and observed that by increasing the value of σ, solitary wave profile exhibits mitigation. We have also observed the solitary structure of the DAW for the kappa cold ions κ_c, and it has been seen that solitary wave profile increases with the increasing value of kappa cold ions κ_c. We have also presented the solitary structure of the nonlinear DAW for cold ion number density n_c and found that by increasing cold ion number density, solitary wave profile experiences a decrease. We have also shown the effect of hot ion population n_h on the solitary structure of the DAW and found that by increasing the hot ion population, the solitary wave profile exhibits an enhancement.

The external periodic force (EPF) has been found to lead to the onset of both quasiperiodic and chaotic structures for the DAW for the planar dynamical system of the mKP equation. We have observed that the frequency ω of the EPF plays a vital role to see the quasiperiodic and chaotic behavior of the nonlinear DAW. It has also been found that by decreasing the value of ω, the system makes a transition from quasiperiodicity to chaos. We have observed islands, necklaces, and archipelago structures in chaos for different values of external periodic frequency ω. We have also shown the most prominent feature of chaos i.e., sensitivity to the initial condition, and observed that a small change in the initial condition has a significant effect on the chaotic structure. Besides the effect of the EPF, we have also presented the effect of plasma parameters on the chaotic structures. It has been noted that by increasing the value of κ_c, the value of the nonlinear coefficient of the mKP equation decreases and the system becomes more chaotic. We have also seen that the system becomes more chaotic for Maxwellian hot and cold ions as compared to their kappa counterparts. We have also explored the effect of nonlinear acoustic speed U and showed that it has almost the same effect on chaotic structures as the frequency of EPF. Interestingly and importantly, we have also seen that periodic initial conditions exhibit rich chaotic structures as compared to solitary initial conditions. We have also investigated the effect of the strength of EPF f_0 and found that by increasing the value of f_0, the system becomes more chaotic.