Title: Existence of Different Solitary Structures in Magnetized Nonthermal Dusty Plasma

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Abstract: In this thesis, we have considered the following problems on the existence of ion acoustic solitary structures including double layers and supersolitons in a magnetized nonthermal dusty plasma.

Problem-1: Here, we have used Sagdeev potential technique to investigate the arbitrary amplitude ion acoustic solitary structures in a collisionless magnetized dusty plasma consisting of negatively charged static dust grains, adiabatic warm ions and nonthermal electrons. The present system supports both positive and negative potential solitary waves, coexistence of solitary waves of both polarities, and negative potential double layers. The system does not support any positive potential double layer. Although the system supports negative potential double layers, but these double layer solutions cannot restrict the occurrence of all solitary structures of same polarity. In fact, there exists a parameter regime for which the negative potential double layer is unable to restrict the occurrence of negative potential solitary waves, and in this region of the parameter space, there exist negative potential solitary waves after the formation of negative potential double layer. Consequently, negative potential supersolitons have been observed and the Mach number M corresponding to a negative potential supersoliton is restricted by the inequality $M_{NPDL} < M < M_{cr}$, but this supersoliton structure reduces to a conventional solitary wave of same polarity if $M \geq M_{cr}$, where M_{NPDL} is the Mach number corresponding to a negative potential double layer and M_{cr} is a critical value of M . Thus, we have seen a transition process of negative potential solitary structures, viz., soliton → double layer → supersoliton → soliton. Different solitary structures have been investigated with the help of compositional parameter spaces and the phase portraits of the dynamical system describing the nonlinear behaviour of ion acoustic waves. The mechanism of transition of a negative potential supersoliton to a conventional soliton after the formation of double layer of same polarity has been discussed with the help of phase portraits.

Problem-2: Here, we have considered the same plasma system as mentioned in **Problem-1**, but we have investigated the existence of ion acoustic solitary structures including double layers and supersolitons at the acoustic speed. At the acoustic speed, for negative polarity, the system supports solitons, double layers, supersoliton structures after the formation of double layer, supersoliton structures without the formation of double layer, solitons after the formation of double layer whereas the system supports solitons and supersolitons without the formation of double layer for the case of positive polarity. But it is not possible to get the coexistence of solitary structures (including double layers and supersolitons) of opposite polarities. For negative polarity, we have observed an important transformation, viz., soliton before the formation of double layer → double layer → supersoliton → soliton after the formation of double layer whereas for both positive and negative polarities, we have observed the transformation from solitons to supersolitons without the formation of double layer. There does not exist any negative (positive) potential solitary structures within $0 < \mu < \mu_c$ $(\mu_c < \mu < 1)$ and the amplitude of the positive (negative) potential solitary structure decreases for increasing (decreasing) μ and the solitary structures of both polarities collapse at $\mu = \mu_c$, where μ_c is a critical value of μ , the ratio of unperturbed number density of electrons to that of ions. Similarly, there exists a critical value β_{e2} of the nonthermal parameter β_e such that the solitons of both polarities collapse at $\beta_e = \beta_{e2}$.

Problem-3: This problem is an extension of **Problem-1** in the following direction: (1) Starting from one dimensional Kappa distribution for electrons, we have systematically developed the combined Kappa-Cairns distribution, (2) we have found the effective bounds of both nonthermal parameters κ and β_e for the combined Kappa-Cairns distribution. This distribution can generate more highly energetic particles in comparison with both Kappa and Cairns distributions. We have investigated ion acoustic solitary structures in a collisionless magnetized plasma composed of negatively charged static dust grains, adiabatic warm ions and a population of highly energetic electrons generated from the combined Kappa-Cairns distribution. Sagdeev pseudo potential technique has been considered to investigate the arbitrary amplitude steady state solitary structures including double layers and supersolitons. We have developed a computational scheme to draw the existence domains showing the nature of existence of different solitary structures. Different solitary structures of both positive and negative polarities have been observed for different values of κ and β_e. We have seen two important transitions of solitary structures for negative polarity, viz., soliton before the formation of double layer $\rightarrow$ double layer $\rightarrow$ supersoliton $\rightarrow$ soliton after the formation of double layer, and soliton before the formation of supersoliton $\rightarrow$ supersoliton $\rightarrow$ soliton. For the second case, we have a supersoliton structure without the formation of double layer and this case is completely new one for magnetized plasma. Different solitary structures supported by the system have been investigated with the help of compositional parameter spaces and the phase portraits of the dynamical systems describing different solitary structures.

Problem-4: Here, the plasma system is same as the plasma system as defined in **Problem-3**, but here we have considered the Poisson equation instead of quasi-neutrality condition along with the different conservation equations to describe the nonlinear behaviour of IA waves. In this problem, we have derived a KdV-ZK (Korteweg-de Vries-Zakharov-Kuznetsov) equation to investigate the oblique propagation of weakly nonlinear and weakly dispersive ion acoustic (IA) waves in a collisionless magnetized plasma consisting of warm adiabatic ions, static negatively charged dust grains and combined Kappa-Cairns distribution of electrons. It is found that a factor (B_1) of the coefficient of the nonlinear term of the KdV-ZK equation vanishes along different families of curves in different parameter planes. In this situation, i.e., when $B_1 = 0$, we have derived a modified KdV-ZK (MKdV-ZK) equation to describe the nonlinear behaviour of ion acoustic waves. We have investigated the solitary wave solutions of these evolution equations propagating obliquely to the direction of the magnetic field. We have also discussed the effect of different parameters of the present plasma system on the amplitude of these solitary wave solutions.

Problem-5: The present problem is an extension of **Problem-1** in the following direction: instead of considering three-component collisionless magnetized plasma consisting of adiabatic warm ions, nonthermal electrons and static negatively charged dust grains, we have considered a collisionless magnetized four-component plasma consisting of adiabatic warm ions, nonthermal electrons, isothermal positrons and static negatively charged dust grains immersed in a static uniform magnetic field directed along a fixed direction. Arbitrary amplitude ion acoustic solitary structures have been investigated in the present plasma system. We have observed that the system supports positive potential solitary waves, negative potential solitary waves, coexistence of solitary waves of both polarities, negative potential double layers, negative potential supersolitons, positive potential supersolitons for different values of the parameters of the system. We have investigated the effect of different parameters of the system on the solitary structures.

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