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Research Article

Effect of Size Distribution on the Dust Acoustic Solitary Waves in Dusty Plasma with Two Kinds of Nonthermal Ions

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Effect of dust size, mass, and charge distributions on the nonlinear dust acoustic solitary waves (DASWs) in a dusty plasma including negatively charged dust particles, electrons, and nonthermal ions has been studied analytically. Dust particles masses and electrical charges are assumed to be proportional with dust size. Using reductive perturbation methods the Kadomtsev-Petviashvili (KP) equation is derived and its solitary answers are extracted. The coefficients of nonlinear term of KP equation are affected strongly by the size of dust particles when the relative size (the ratio of the largest dust radius to smallest dust radius) is smaller than 2. These coefficients are very sensitive to α, the nonthermal coefficient. According to the results, only rarefactive DASWs will generate in such dusty plasma. Width of DASW increases with increasing the relative size and nonthermal coefficient, while their amplitude decreases. The dust cyclotron frequency changes with relative size of dust particles.

1. Introduction

The study of dusty plasmas represents one of the most rapidly growing branches of plasma physics. A dusty plasma is an ionized gas containing small particles of solid matter, which acquire a large electric charge by collecting electrons and ions from the plasma. Dust grains or particles are usually highly charged. Charged dust components appear naturally in space environments such as planetary rings, cometary surroundings, interstellar clouds, and lower parts of earth's ionospheres [1–4]. Fusion reactors, film deposition reactors, and ions courses are other examples of dusty plasma systems in laboratory. Since dust particles are relatively massive, the frequency of DASW is typically few Hz and propagates at a speed of a few cm/s. This wave is spontaneously excited in the plasma due to ion drift relative to the dust. In most investigations, reductive perturbation method has been used for deriving the Korteweg de Vries (KdV) or modified KdV equations in one-dimensional studies [5–8] or Kadomstev-Petviashvili (KP) equation for two-dimensional cases [9, 10].

There are many reports on the formation and propagation of DASW in dusty plasma. But far from ideal condition, there are several phenomena which affect the DASW. Presence of nonthermal particles and size distribution are two of them. A nonthermal plasma is in general any plasma which is not in thermodynamic equilibrium, either because the ion temperature is different from the electron temperature, or because the velocity distribution of one of the species does not follow a Maxwell-Boltzmann distribution. The effects of dust temperature and dust charge variation in a dusty plasma with nonthermal ions have been investigated by Duan [11]. Pakzad and Javidan have worked on the problem of variable dust charge in a dusty plasma with two-temperature ions with nonthermal electrons [12, 13]. Dorranian and Sabetkar have investigated the characteristic features of dust particles in a dusty plasma with two ions at two different temperatures and have observed the effect of nonthermal ions on the amplitude and width of DASW [14]. All of these theories have focused on dusty plasma containing only monosized dust grains. In fact, the dust particles have many different species of size [15–17]. The dust size distribution can be described by a power law distribution in space plasma and given by a Gaussian distribution in laboratory plasma [18]. The effects of dust size distribution on the dust acoustic waves, solitons, or instabilities in a dusty plasma have been studied by several researchers previously [15, 17]. The effect of dust size distribution for two ion temperature dusty plasma in one dimension (KdV equation) was studied by Duan and Shi [19]. He et al. observed the effect of dust size distribution on the nature of DASW in two dimensions (KP equation) [20]. In this work the collective behavior of dust particles is not considered, and the effect of relative size is not taken into account.

Continuing the former works, we have added the effect of dust size distribution to the model which contains two nonthermal ions at two temperatures, including Maxwellian electrons. In this paper, characteristic features of dust particles with variable size, mass, and electric charge in a nonthermal two-temperature ions dusty plasma are investigated. The mass and charge of dust particles are assumed to be proportional with their size. The paper is organized as follow: following the introduction in Section 1, in Section 2, we present the model description and the theoretical aspects of the model. The KP equation and its solitary answer are derived and described in this section. Section 3 is devoted to results and discussion, and Section 4 includes the conclusion.

2. Model Description

2.1. Basic Equations. We consider the propagation of DASW in collisionless, unmagnetized dusty plasma consisting of highly negatively charged dust grains, electrons, and two-temperature nonthermal ions. The dust particles are much larger and extremely more massive than ions or electrons, but the sizes of dust grains are different. We shall assume that there are N number of different dust grains sizes whose masses are $m_{dj}(j = 1, 2, \ldots N)$. In this case we have different species of dusts with different size, which is counted with j. Plasma is assumed to be quasineutral. The state of charge neutrality can be written as

$$n_{e0} + \sum_{j=1}^{N} n_{dj0} Z_{dj0} - n_{il0} - n_{ih0} = 0 \qquad (1)$$

in which n_{e0}, n_{il0}, and n_{ih0} are the unpertubrbed number density of electrons, low-temperature ions, and high-temperature ions, respectively. Z_{dj0} is the unperturbed number of charges residing on the jth dust grain measured in the unit of electron charge. The dust grains are assumed to be much smaller than electron Debye length λ_{de} as well as the intergrain distance. Thus, we can treat the dust grains as heavy point masses with constant negative charge [21]. The governing equations including the normalized Poisson's equation, continuity equation, and the equation of motion describing the dynamics of the dust particles in the plasma are

$$\frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} = n_e + \sum_{j=1}^{n} n_{dj} Z_{dj} - n_{il} - n_{ih}, \qquad (2a)$$

$$\frac{\partial n_{dj}}{\partial t} + \frac{\partial \left(n_{dj} u_{dj}\right)}{\partial x} + \frac{\partial \left(n_{dj} v_{dj}\right)}{\partial y} = 0, \qquad (2b)$$

$$\frac{\partial u_{dj}}{\partial t} + u_{dj} \frac{\partial u_{dj}}{\partial x} + v_{dj} \frac{\partial u_{dj}}{\partial y} = \frac{z_{dj}}{m_{dj}} \frac{\partial \phi}{\partial x}, \qquad (2c)$$

$$\frac{\partial v_{dj}}{\partial t} + u_{dj} \frac{\partial v_{dj}}{\partial x} + v_{dj} \frac{\partial v_{dj}}{\partial y} = \frac{z_{dj}}{m_{dj}} \frac{\partial \phi}{\partial y}. \qquad (2d)$$

In these equations, ϕ is the electrostatic potential; n_e, n_{il}, and n_{ih} are the number density of electrons, low-temperature ions and high-temperature ions respectively. Z_{dj} and n_{dj} are the charge number and the density number of the jth species of dust particles, respectively. e is the basic charge magnitude. u_{dj} and v_{dj} are the components of the velocity of jth species of dust particles in the x- and y-directions, respectively. For the case of dusty plasma with two kinds of ions at different temperatures, T_{eff}, the effective temperature is

$$T_{\text{eff}} = \left[\frac{1}{N_{\text{tot}} \overline{z_{d0}}} \left(\frac{n_{e0}}{T_e} + \frac{n_{il0}}{T_{il}} + \frac{n_{ih0}}{T_{ih}} \right) \right]^{-1}, \qquad (3)$$

in which T_e, T_{il}, and T_{ih} are the plasma electron temperature and the temperatures of plasma ions at lower and higher temperatures, respectively. N_{tot} is the total number density of dust grains which can be written as $N_{\text{tot}} = \sum_{j=1}^{N} n_{d0j}$; $\overline{z_{d0}}$ is determined by the equation $\overline{z_{d0}} N_{\text{tot}} = \sum_{j=1}^{N} n_{d0j} z_{d0j}$. $\overline{a}$ is the average radii of dust size given by $\overline{a} = \sum_{j=1}^{N} n_{d0j} a_j / N_{\text{tot}}$. The dust density is normalized by N_{tot}; z_{doj} is normalized by $\overline{z_{d0}}$. The space coordinates x and y, time t, the components of dust velocity u_{dj}, v_{dj}, and the electrostatic potential ϕ are normalized by the effective Debye lenght $\lambda_{Dd} = (T_{\text{eff}}/4\pi N_{\text{tot}} \overline{Z_{d0}} e^2)^{1/2}$, the inverse of effective dust plasma frequency $\omega_{pd}^{-1} = (\overline{m_d}/4\pi N_{\text{tot}} \overline{Z_{d0}}^2 e^2)^{1/2}$, the effective dust acoustic speed $C_d = (\overline{z_{d0}} T_{\text{eff}}/\overline{m_d})^{1/2}$, and T_{eff}/e, respectively, where $\overline{m_d}$ is the average mass of dust grains determined by the equation of $\overline{m_d} = \sum_{j=1}^{N} n_{d0j} m_{dj} / N_{\text{tot}}$; m_{dj} is normalized by $\overline{m_d}$.

Ions in the plasma are assumed to be nonthermal, so their density can be described by the known Maxwell Boltzmann distribution function. For the dimensionless density number of electrons, n_e, lower temperature ions, n_{il}, and higher temperature ions, n_{ih}, we have

$$n_e = \frac{1}{\delta_1 + \delta_2 - 1} \exp\left(\beta_1 s\phi\right), \tag{4a}$$

$$n_{il} = \frac{\delta_1}{\delta_1 + \delta_2 - 1} \left(1 + \frac{4\alpha}{1+3\alpha} s\phi + \frac{4\alpha}{1+3\alpha} (s\phi)^2\right) \exp\left(-s\phi\right), \tag{4b}$$

$$n_{ih} = \frac{\delta_2}{\delta_1 + \delta_2 - 1} \times \left(1 + \frac{4\alpha}{1+3\alpha} \beta_3 s\phi + \frac{4\alpha}{1+3\alpha} (\beta_3 s\phi)^2\right) \exp\left(-\beta_3 s\phi\right), \tag{4c}$$

in which $\beta_1 = T_{il}/T_e$, $\beta_2 = T_{ih}/T_e$, $\beta_3 = \beta_1/\beta_2$, $\delta_1 = n_{il0}/n_{e0}$, $\delta_2 = n_{ih0}/n_{e0}$, and $s = T_{\text{eff}}/T_{il} = \delta_1 + \delta_2 - 1/\delta_1 + \delta_2\beta_3 + \beta_1$. α is the nonthermal parameter that determines the number of fast (nonthermal) ions [22, 23].

2.2. The KP Equation. In this part by using the basic equations, the so called KP equation in the plasma with variable dust particle electric charge is derived. KP equation is a fundamental equation, and its solution describes the characteristic of DASW in detail. In order to simplify the equations based on the reductive perturbation theory, it is useful to introduce three independent variables [24]:

$$\xi = \varepsilon (x - \lambda t), \tag{5a}$$

$$\tau = \varepsilon^3 t, \tag{5b}$$

$$\eta = \varepsilon^2 y, \tag{5c}$$

in which ε is the dimensionless expansion parameter and characterizes the strength of the nonlinearity of the system. λ is the phase velocity of the wave along the x direction. Different parameters of the dust particles can be expanded in terms of ε as

$$n_{dj} = n_{dj0} + \varepsilon^2 n_{dj1} + \varepsilon^4 n_{dj2} + \cdots, \tag{6a}$$

$$u_{dj} = \varepsilon^2 u_{dj1} + \varepsilon^4 u_{dj2} + \cdots, \tag{6b}$$

$$v_{dj} = \varepsilon^3 v_{dj1} + \varepsilon^5 v_{dj2} + \cdots, \tag{6c}$$

$$\phi = \varepsilon^2 \phi_1 + \varepsilon^4 \phi_2 + \cdots. \tag{6d}$$

By substituting (5a), (5b), (5c), (6a), (6b), (6c), and (6d) in (2a), (2b), (2c), and (2d) and collecting the coefficient of the lowest order of ε, we have

$$n_{dj1} = -\frac{n_{dj0} z_{dj}}{\lambda^2 m_{dj}} \phi_1, \qquad u_{dj1} = -\frac{z_{dj}}{\lambda m_{dj}} \phi_1, \qquad \frac{\partial v_{dj1}}{\partial \xi} = -\frac{z_{dj}}{\lambda m_{dj}} \frac{\partial \phi_1}{\partial \eta}, \tag{7}$$

$$\lambda = \left[\sum_{j=1}^{N} \frac{n_{dj0} z_{dj}^2}{m_{dj}} \frac{\left(\delta_1 + \delta_2\beta_3 + \beta_1\right)(1+3\alpha)}{(1+3\alpha)\beta_1 + (1-\alpha)\left(\delta_1 + \delta_2\beta_3\right)}\right]^{1/2}. \tag{8}$$

Tending $\alpha \rightarrow 0$ results are the same as the results presented by He et al. [20], and neglecting the effect of size distribution, equations are the same with the results published by Dorranian and Sabetkar [14]. For the higher power of ε, we have

$$\frac{\partial n_{dj1}}{\partial \tau} - \lambda \frac{\partial n_{dj2}}{\partial \xi} + \frac{\partial \left(n_{dj0} u_{dj2}\right)}{\partial \xi} + \frac{\partial \left(n_{dj1} u_{dj1}\right)}{\partial \xi} + \frac{\partial \left(n_{dj0} v_{dj1}\right)}{\partial \eta} = 0, \tag{9a}$$

$$\frac{\partial u_{dj1}}{\partial \tau} - \lambda \frac{\partial u_{dj2}}{\partial \xi} + u_{dj1} \frac{\partial u_{dj1}}{\partial \xi} = \frac{z_{dj}}{m_{dj}} \frac{\partial \phi_2}{\partial \xi} \tag{9b}$$

$$\frac{\partial v_{dj1}}{\partial \tau} - \lambda \frac{\partial v_{dj2}}{\partial \xi} + u_{dj1} \frac{\partial v_{dj1}}{\partial \xi} = \frac{z_{dj}}{m_{dj}} \frac{\partial \phi_2}{\partial \eta}, \tag{9c}$$

$$\frac{\partial^2 \phi_1}{\partial \xi^2} = \sum_{j=1}^{N} n_{dj2} z_{dj} + \frac{(1+3\alpha)\beta_1 + (1-\alpha)\left(\delta_1 + \delta_2\beta_3\right)}{\left(\delta_1 + \delta_2\beta_3 + \beta_1\right)(1+3\alpha)} \phi_2 - \frac{s^2\left(\delta_1 + \delta_2\beta_3^2 - \beta_1^2\right)}{2\left(\delta_1 + \delta_2 - 1\right)} \phi_1^2. \tag{9d}$$

Using (9a), (9b), (9c), and (9d) the KP equation for a unmagnetized dusty plasma with two ions can be derived as

$$\frac{\partial}{\partial \xi}\left[\frac{\partial \phi_1}{\partial \tau} + A\phi_1 \frac{\partial \phi_1}{\partial \xi} + B \frac{\partial^3 \phi_1}{\partial \xi^3}\right] + C \frac{\partial^2 \phi_1}{\partial \eta^2} = 0, \tag{10}$$

in which

$$A = \frac{\lambda}{2} \frac{\left(\delta_1 + \delta_2\beta_3^2 - \beta_1^2\right)\left(\delta_1 + \delta_2 - 1\right)}{\left(\delta_1 + \delta_2\beta_3 + \beta_1\right)^2} \frac{\left(\delta_1 + \delta_2\beta_3^2 - \beta_1^2\right)}{\left(\delta_1 + \delta_2 - 1\right)} \times \frac{\left(\delta_1 + \delta_2\beta_3 + \beta_1\right)(1+3\alpha)}{(1+3\alpha)\beta_1 + (1-\alpha)\left(\delta_1 + \delta_2\beta_3\right)} - \frac{3}{2\lambda^3} \sum_{j=1}^{N} \frac{n_{dj0} z_{dj}^3}{m_{dj}^2} \frac{\left(\delta_1 + \delta_2\beta_3 + \beta_1\right)(1+3\alpha)}{(1+3\alpha)\beta_1 + (1-\alpha)\left(\delta_1 + \delta_2\beta_3\right)}, \tag{11}$$

$$B = \frac{\lambda}{2} \frac{\left(\delta_1 + \delta_2\beta_3 + \beta_1\right)(1+3\alpha)}{(1+3\alpha)\beta_1 + (1-\alpha)\left(\delta_1 + \delta_2\beta_3\right)}, \tag{12}$$

$$C = \frac{\lambda}{2}. \tag{13}$$

For dust grains with radii a in a given range $[a_{\min}, a_{\max}]$, the differential polynomial expressed distribution function is of the form [19]

$$n(a)\, da = K a^{-\beta} da. \tag{14}$$

It is found that values of $\beta = 4, 5$ for the F-ring of Saturn, while for the G-ring values of $\beta = 7$ or 6. For cometary environments, we recall a value of $\beta = 3,4$. K is a normalization constant, and a is the radii of dust particle, which should satisfy the following equation [19]:

$$n_{\text{tot}} = \int_{a_{\min}}^{a_{\max}} n(a)\, da. \tag{15}$$

Outside the limits $a_{\min} < a < a_{\max}$, we have $n_a = 0$. In the equations $z_{dj} = k_z a_j$ and $m_{dj} = k_m a_j^3$, $k_z = 4\pi\varepsilon_0 v_0/e$ is the electrical potential of the surface of dust particles at equilibrium. $k_m = 4/3\pi\rho_d$, in which ρ_d is the mass density of dust particles, ρ_d is taken to be constant for all dust particles, v_0 is the electric surface potential at equilibrium, and ε_0 is the vacuum permittivity [25]. Integrating (8), (11), using the previous definitions, we have

$$\lambda = \left[\frac{(\delta_1 + \delta_2\beta_3 + \beta_1)(1+3\alpha)}{(1+3\alpha)\beta_1 + (1-\alpha)(\delta_1+\delta_2\beta_3)} \times \frac{Kk_z^2}{k_m\beta}\left(a_{\min}^{-\beta} - a_{\max}^{-\beta}\right)\right]^{1/2},$$

$$A = \frac{\lambda}{2}\frac{\left(\delta_1 + \delta_2\beta_3^2 - \beta_1^2\right)(\delta_1+\delta_2-1)}{(\delta_1+\delta_2\beta_3+\beta_1)^2}\frac{\left(\delta_1+\delta_2\beta_3^2-\beta_1^2\right)}{(\delta_1+\delta_2-1)} \times \frac{(\delta_1+\delta_2\beta_3+\beta_1)(1+3\alpha)}{(1+3\alpha)\beta_1+(1-\alpha)(\delta_1+\delta_2\beta_3)} + \frac{3Kk_z^3}{2\lambda^3 k_m^2(\beta+2)}\frac{(\delta_1+\delta_2\beta_3+\beta_1)(1+3\alpha)}{(1+3\alpha)\beta_1+(1-\alpha)(\delta_1+\delta_2\beta_3)} \times \left(a_{\max}^{-\beta-2} - a_{\min}^{-\beta-2}\right). \tag{16}$$

The general steady state solution of (10) for ϕ_1 has the form [14]

$$\phi_1 = \phi_m \operatorname{sech}^2\left(\frac{\chi}{w}\right), \tag{17}$$

in which the new variable $\chi = \xi + \eta - u\tau$ is the transformed coordinate relative to the frame which moves with the velocity u [14]; $\phi_m = 3(u-C)/A$ and $w = 2\sqrt{B/(u-C)}$ are the amplitude and width of soliton, respectively. The coefficients of KP equation would change to the results presented in [14, 20] in case neglecting of nonthermal effects and size distribution effects, respectively.

3. Results and Discussion

Effects of ions temperature and density on the coefficients of KP equation are very small. In other words, variations of ions temperature and density lead to negligible effects on the coefficients of KP equation in this model.

To plot our data, $a_{\min}$ is taken to be unity. In order to avoid the effects of ions density and temperature, β_1 and β_2 are taken to be equal to 0.25, and δ_1 and δ_2 are both taken to be 2.

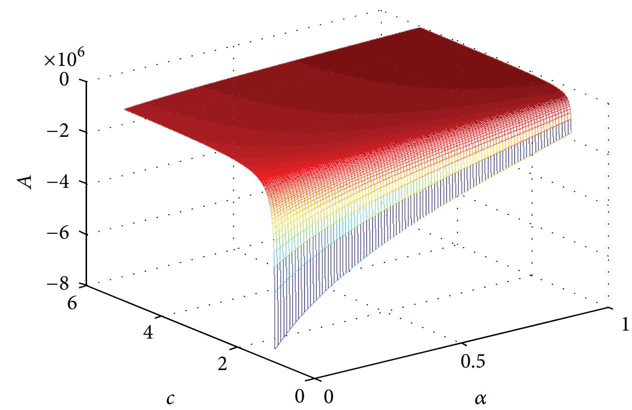

Figure 1: Variation of A versus c and α.

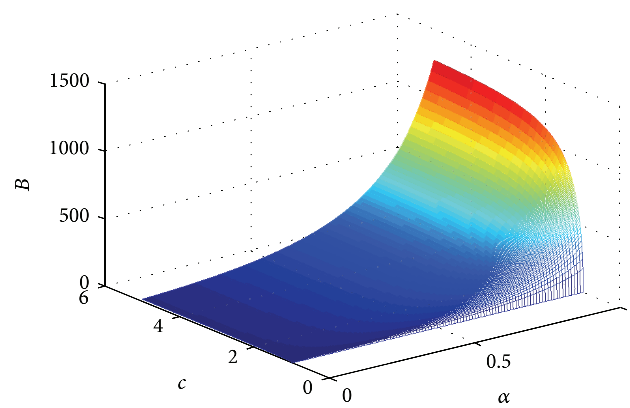

Figure 2: Variation of B versus c and α.

For a typical dusty plasma [19], $n_{i0} \sim 10^5$–$10^{10}\,\text{cm}^{-3}$, $T_i \sim T_e \sim 0.1\,\text{eV}$, $n_{d0} \sim 10^5\,\text{cm}^{-3}$, $Q_d \sim (-10^4\,\text{e})$–$(-10^5\,\text{e})$, $m_d \sim 10^{-15}$–$10^{-12}\,g \sim 10^9$–$10^{12}\,\text{m}$, $\rho_d \sim 1\,\text{g/cm}^3$, and $a \sim 0.1$–$1\,\mu\text{m}$, so it can be estimated that $k_m = 4$, $k_z = 10^8$, and $K = 10^{-12}$. Here β is taken to be 6.

The variation of the nonlinear coefficient, A, with the maximum dust size ratio $c = a_{\max}/a_{\min}$ and the nonthermal coefficient α is presented in Figure 1. A increases with increasing c. For all the ranges of $1 < c < 5$ and $0 < \alpha < 1$, the nonlinear coefficient A is negative, mean that in this range of variation only rarefactive solitons will be generated in dusty plasma, and it is not useful to continue our work for modified KP equation. This point is similar with the presented results in [20] in which the effect of size distribution is taken into account. But in Dorranian and Sabetkar's work [14], in the presence of thermal effect without size distribution effect, just in the case of small α, rarefactive soliton will appear in the dusty plasma medium. As the function of c, A varies faster when $1 < c < 2$. When the magnitude of the maximum ratio of dust size is larger than 2, A is approximately constant. With increasing α also A increases. Variation of A with α is larger when $1 < c < 2$. With increasing c, the effect of α decreases. Effect of α is noticeable when c is small.

Effects of c and α on B are presented in Figure 2. In contrast with A, effect of α on B is noticeable when c is large.

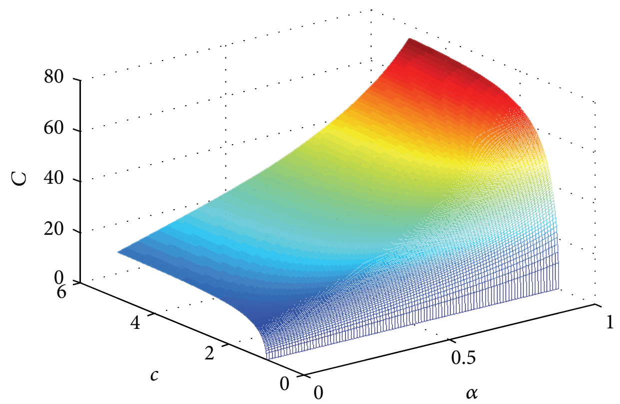

Figure 3: Variation of C versus c and α.

For $c \to 1$, the coefficient B is not changed with α. The same result can be seen for c. When α is small, B is not changed with c. When nonthermality is high, increasing the maximum ratio of dust size leads to increasing the coefficient B of KP equation.

The same effect are occurred for the coefficient C. Effect of c on C is noticeable when α tends to 1, and C increases fast with α when c tends to 5 as is shown in Figure 3.

Width of generated soliton in this model strongly depends on c and α. This dependence is shown in Figure 4. In any case, solitons are broadened with increasing c and α. The broadest soliton generates when α and c are maximum at the same time. The same results have been obtained in Dorranian and Sabetkar's paper when the effect of size distribution was not taken into account [14]. The rate of increasing soliton width with α is smaller in the presence of size distribution effect.

Profiles of generated solitons in dusty plasma regarding the requirements of our model are presented in Figures 5 and 6. In Figure 5, the effect of α is shown, when $c = 5$. With increasing α, the width of generated solitons increases while their amplitude decreases. This result is in good agreement with the results of works in which the effect of size distribution is neglected [14]. With increasing c also the amplitude of generated solitons decreases but their width is increased.

α is the nonthermal coefficient which changes the distribution function of ions from Boltzman distribution. Increasing α leads to increasing the energy of ions in the dusty plasma medium or decreasing the dust particles energy. With decreasing the energy of dust particles, the amplitude of solitons decreases. Less energetic particles are more localized, so the width of generated solitons increases with increasing α.

c is the ratio of the maximum dust particle size to the minimum dust particle size. With increasing c the width of the size distribution function of dust particles is increased, while their amplitude decreases. Increasing c is actually increasing the dust species. In this case, we have larger variety of dust particles accompanied in solitonic oscillation. Increasing the ratio of dust particles size leads to increasing the perturbation in their uniform motion. The result will be reducing the amplitude of solitons. Different size particles moving with different velocities lead to generating less localized oscillations.

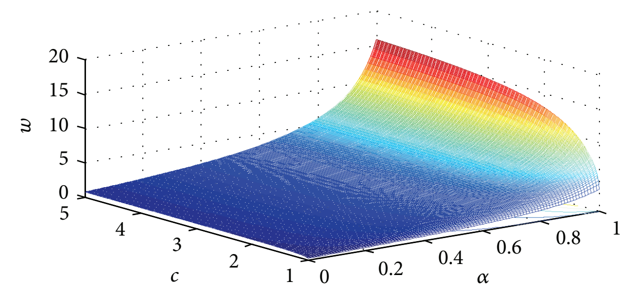

Figure 4: Variation of width versus c and α.

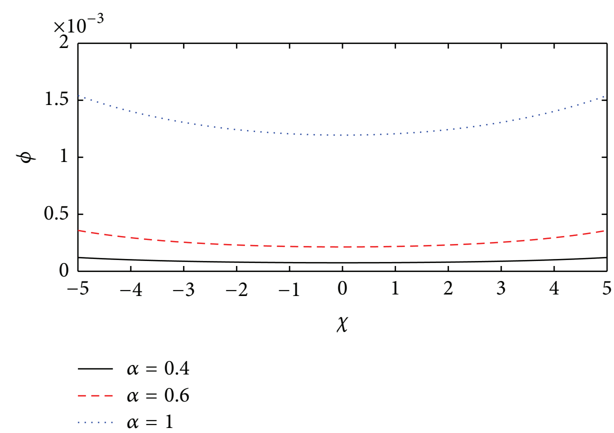

Figure 5: The profile of soliton at different αs, when $c = 5$.

4. Conclusion

In the present paper, nonlinear dust acoustic solitary waves (DASWs) in a cold unmagnetized dusty plasma containing negatively charged dust particles, electrons, and nonthermal ions are investigated. The size of dust particles is taken to be variable, and the charge and mass of dust particles are supposed to be proportional with their size. For this purpose, a reasonable normalization of the hydrodynamic and Poisson's equations is used to derive the Kadomstev-Petviashvili (KP) equation for our dusty plasma system.

In this model DASWs are found to be rarefactive for all magnitudes of the maximum ratio of dust size c and α. In this case, soliton nature is under the influence of size distribution rather than nonthermal ions, since in the presence of nonthermal ions without taking into account the effect of size distribution in both rarefactive and compressive solitons have been observed [14]. But, the results of the model in which the effect of size distribution is taken into account is only generation of rarefactive solitons is reported [26].

For $1 < c < 5$, amplitude of DASW varies noticeably with c rather than temperature and density of two species of dusts particles. With increasing c, the amplitude of DASW decreases sharply, and for $c > 2$ it is almost independent of c. With decreasing the nonthermal coefficient, the amplitude

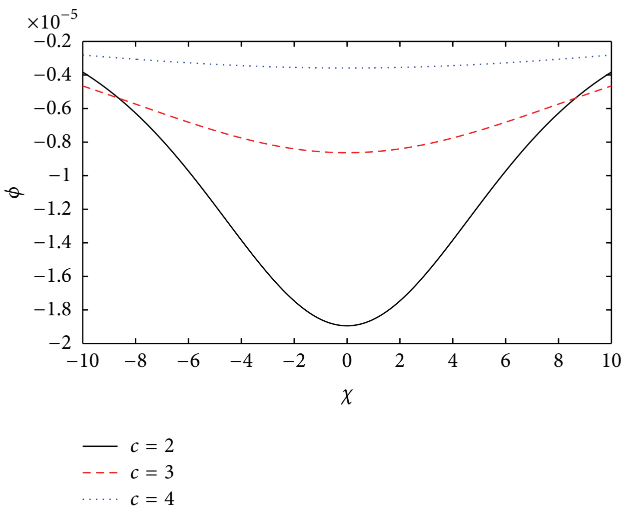

FIGURE 6: The profile of soliton at different cs, when $\alpha = 0.2$.

of DASW increases. The same results have been reported by Dorranian and Sabetkar [14]. Decreasing the ratio of maximum size of dust to its minimum magnitude leads to generation of more localized solitons, that is, decreasing the width of DASW. The most energetic, localized solitons are when $c = 1$ that is, there is not any size, mass, or charge distribution for dusts. Since in this case the dusty plasma medium is uniform, it leads to formation of less perturbation in the medium.

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