International Journal of Research and Review
www.ijrrjournal.com E-ISSN: 2349-9788; P-ISSN: 2454-2237

Research Paper

Nonperturbative Technique for Dust-Ion-Acoustic Waves in Dusty Plasma with Nonthermal Electrons

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ABSTRACT

The existence of dust ion-acoustic waves (DIAWs) and its propagation in multicomponent dusty plasma is studied with the help of fluid model. The dust particles are considered as negatively charged and the electrons are taken as nonthermal. Applying nonperturbative technique Sagdeev Potential equation is derived to study the existence of arbitrary amplitude solitary wave. Solution of small amplitude solitary wave is obtained in the form of $\operatorname{sec}h$ equation. Variation of amplitude and width of small amplitude solitary waves with the values of the parameters viz. wave Mach number, population of nonthermal electrons, density ratio, temperature ratio and mass ration, are observed. The values of the parameters are chosen according to the physical consideration of the plasma model.

Keywords: [Dusty plasma, Dust-ion-acoustic waves, nonthermal electrons, nonperturbative]

INTRODUCTION

Plasma is a very complex state of dispersive matter occupying most parts of the universe. In order to understand the basic properties of the nonlinear solitary waves propagating in plasma, we are to consider the effect of the characteristic frequencies of the different plasma species, leading to the coherent oscillations of the charged particles of plasma. Due to the dispersive character of plasma, the coherence of the nonlinearity gets reduced. As a result, some typical balance between nonlinearity and dispersion occurs and the resulting wave structure propagates without change of size and shape for long time. Such waves, called solitary waves or solitons are finite energy structures. Recent trend of research in the field of nonlinear plasma waves shows high interest of mathematicians and plasma scientists. The nonlinearity of plasma which leads to the formation and propagation of nonlinear solitary waves was studied by many researchers. [1-5]

The different plasma species have great influence on the collective behaviour of the medium. Due to the heavy mass of dust grains in comparison to ions and electrons, they can have interaction with both and can be charged both positively or negatively. Negatively charged dust particles can give rise to new kind of nonlinear plasma wave modes. Baluku & Hellberg. [6] studied both small & large amplitude dust acoustic solitary waves. The study of dusty plasma has become more important after the publication of Rao et.al. on dust acoustic wave mode for the first time. [1] Dusty plasma is a complex plasma medium consisting of dispersed kind of solid grains of micron or submicron level of size. [7] Effect of dust like grains was studied in the laboratory by Langmuir et.al. [8] In the process of dusty plasma wave formation, the presence of charged dust species plays very important dynamical role. As a result, the collective behaviour depends on density, charge, temperature and other properties of the dust species. Most of the dusty plasma wave studies are seen to consider negatively charged dust species since the high mobility of the electrons leads to quick charging due to contact with the dust particles. Generally, the ions are considered as Maxwellian because of the considerable mass difference between the ions and the dust particles. However in nonthermal plasma, ions can perform non Maxwellian behavior also. Basically the electron thermal energy has been considered effectively in many forms viz. Maxwellian, inertial and nonthermal character in such wave studies.

Nonlinear waves in dusty plasma are generally studied by means of two normal wave modes, viz. dust acoustic solitary waves and dust ion acoustic solitary waves. These waves are produced due to the transient behaviour of the medium as a result of different types of oscillations of the constituent components (both charged and neutrals). Rahman and Mamun had theoretically investigated dust ion acoustic wves in warm dusty plasmas in presence of vortex-like distributed trapped electrons and cold ions. [9] Duha et.al investigated dust ion acoustic waves in multicomponent dusty plasmas consisting of trapped electrons and Maxwellian ions with stationary dust grains having variable dust charge. [10] Shukla and Silin pointed out about the existence of a new low frequency electrostatic wave in unmagnetized dusty plasma in 1992. [11] Later, Bacha et.al extended their analysis to study dust ion acoustic waves in dusty plasma having self consistent dust charge fluctuations with nonextensive electrons. [12]

Most of the problems in plasmas are treated by perturbation technique. But higher order approximations are not negligible in case of the large amplitude waves. So perturbation technique is not adequate to study such waves. Therefore a variety of nonperturbative approaches were developed by many researchers. [13-14] In order to study the plasma acoustic waves of arbitrary amplitude derived by nonperturbative approach known as Sagdeev (1966) Potential analysis. [15] However the method was first discussed by Davis *et al.* (1958) [16] in the context of fluid dynamics. Exact solution of the differential equations describing full nonlinearity can be obtained through a standard method known as the Sagdeev's Pseudpotential (SP) method. Pseudopotential shows the motion of the oscillatory charged particles by energy integral equation having unit mass whose pseudoposition is ϕ and pseudovelocity is $\frac{d\phi}{d\xi}$ in a pseudopotential well $S(\phi)$.

In this paper we have considered a fluid model of plasma governed by a set of basic equations consisting of continuity and motion equation of dust and ions, nonthermal equation of electrons followed by the Poisson's equation. By applying nonperturbative technique the Sagdeev Potential equation has been derived. The solution for small amplitude solitary waves is derived to know the nature of the solitary wave. The variations in amplitude and width of the solitary wave have been studied for different values of the parameters.

Basic Equations

We have considered the following one dimensional, colisionless, unmagnetized dust-ion- acoustic plasma model consisting of nonthermal electrons, Maxwellian ions and extremely massive negatively charged dust particles with pressure terms. The basic equations are:

For ions,

$$\frac{\partial n_i}{\partial t}+\frac{\partial}{\partial x}\left(n_i v_i\right)=0 \quad (1)$$

$$\frac{\partial v_i}{\partial t}+v_i\frac{\partial v_i}{\partial x}+\frac{\sigma}{\mu n_i}\frac{\partial p_i}{\partial x}=-\frac{\partial \phi}{\partial x} \quad (2)$$

$$\frac{\partial p_i}{\partial t}+v_i\frac{\partial p_i}{\partial x}+3p_i\frac{\partial v_i}{\partial x}=0 \quad (3)$$

For dust,

$$\frac{\partial n_d}{\partial t}+\frac{\partial}{\partial x}\left(n_d v_d\right)=0 \quad (4)$$

$$\frac{\partial v_d}{\partial t} + v_d \frac{\partial v_d}{\partial x} + \frac{\sigma}{Q' n_d} \frac{\partial p_d}{\partial x} = \frac{1}{Q'} \frac{\partial \phi}{\partial x} \quad (5)$$

$$\frac{\partial p_d}{\partial t} + v_d \frac{\partial p_d}{\partial x} + 3 p_d \frac{\partial v_d}{\partial x} = 0 \quad (6)$$

For nonthermal electrons,

$$n_e = \left(1 - \beta\phi + \beta\phi^2\right) \exp(\phi) \quad (7)$$

Poisson's equation,

$$\frac{\partial^2 \phi}{\partial x^2} = n_d + (\mu - 1) n_e - \mu n_i \quad (8)$$

Overall charge neutrality is given by,

$$z_d n_{d0} + n_{e0} - n_{i0} = 0 \quad (9)$$

where, $\sigma = \frac{T_i}{T_e} = \frac{T_d}{T_e}$, $\mu = \frac{n_{i0}}{z_d n_{d0}}$, $Q' = \frac{m_d}{m_i}$, $\beta = \frac{4\alpha}{1+3\alpha}$, α being the population of nonthermal electrons. [17]

The symbols $n_j\,(j = i, d, e)$ denote respectively the density of ions, dust and electrons and $n_{j0}\,(j = i, d, e)$ represent their unperturbed values. $v_j\,(j = i, d)$ and $p_j\,(j = i, d)$ are the velocities and pressures of ion and dust respectively, and ϕ is the plasma potential. $T_j\,(j = i, d, e)$ are the temperatures of ions, dust and electrons, $m_j\,(j = i, d)$ are the mass of ions and dust particles and z_d is the number of dust charged particles.

We have normalized densities n_j by their unperturbed densities n_{j0}, velocities v_i and v_d by ion acoustic speed $C_s = \left(\frac{k z_d T_e}{m_i}\right)^{\frac{1}{2}}$, pressures p_i and p_d by $k z_d n_{d_0} T_e$, time variable t by inverse of the ion plasma frequency $\omega_{pi}^{-1} = \left(\frac{m_i}{4\pi e^2 z_d^2 n_{d0}}\right)^{\frac{1}{2}}$, space variable x by dust Debye length $\lambda_{De} = \left(\frac{k T_e}{4\pi e^2 z_d n_{d0}}\right)^{\frac{1}{2}}$, and plasma potential ϕ by $\frac{kT_e}{e}$, where e is the charge of electrons and k is the Boltzmann constant.

Derivation of Sagdeev Potential Equation

To derive the Sagdeev Potential equation from the above basic equations, we consider the transformation,

$$\xi = x - Mt \quad (10)$$

where M is the wave Mach number, so that the partial derivative operators can be expressed as,

$$\frac{\partial}{\partial x} = \frac{d}{d\xi} \text{ and } \frac{\partial}{\partial t} = -M \frac{d}{d\xi}.$$

With the application of (10), the equations (1) and (3) give,

$$v_i = M\left(1 - \frac{1}{n_i}\right) \quad (11)$$

$$p_i = n_i^3 \quad (12)$$

Using (10), (11) and (12) in equation (2), we get

$$\frac{3\sigma}{2\mu} n_i^4 - \left(\frac{M^2}{2} + \frac{3\sigma}{2} - \phi\right) n_i^2 + \frac{M^2}{2} = 0$$

(13)

In deriving (11), (12) and (13), we have used the boundary conditions as,

$v_i \to 0, \phi \to 0$ when $n_i \to 1$

The equation (13) is a fourth degree equation in n_i. Solving this for n_i^2, we get

$$n_i^2 = \frac{\left(\frac{M^2}{2} + \frac{3\sigma}{2\mu} - \phi\right) \pm \sqrt{\left(\frac{M^2}{2} + \frac{3\sigma}{2\mu} - \phi\right)^2 - 3\sigma M^2}}{\frac{3\sigma}{\mu}}$$

(14)

To obtain n_i, we assume that,

$$n_i = \sqrt{p} - \sqrt{q} \quad (15)$$

So that,

$$n_i^2 = p + q - 2\sqrt{pq} \quad (16)$$

Considering the negative sign of $\pm$ in (14) and comparing with (16), the values of p and q are calculated as,

$$p=\frac{\left(M+\sqrt{\frac{3\sigma}{\mu}}\right)^2-2\phi}{\frac{12\sigma}{\mu}} \qquad q=\frac{\left(M-\sqrt{\frac{3\sigma}{\mu}}\right)^2-2\phi}{\frac{12\sigma}{\mu}}$$

Using these values of p and q in (15), n_i is obtained as,

$$n_i=\frac{1}{2\sqrt{\frac{3\sigma}{\mu}}}\left[\left\{\left(M+\sqrt{\frac{3\sigma}{\mu}}\right)^2-2\phi\right\}^{\frac{1}{2}}-\left\{\left(M-\sqrt{\frac{3\sigma}{\mu}}\right)^2-2\phi\right\}^{\frac{1}{2}}\right] \quad (17)$$

In a similar way, from the equations (4)-(6), n_d can be calculated as,

$$n_d=\frac{1}{2\sqrt{\frac{3\sigma}{Q'}}}\left[\left\{\left(M+\sqrt{\frac{3\sigma}{Q'}}\right)^2+\frac{2\phi}{Q'}\right\}^{\frac{1}{2}}-\left\{\left(M-\sqrt{\frac{3\sigma}{Q'}}\right)^2+\frac{2\phi}{Q'}\right\}^{\frac{1}{2}}\right] \quad (18)$$

Equation (8) becomes,

$$\frac{d}{d\xi}\left[\frac{1}{2}\left(\frac{d\phi}{d\xi}\right)^2\right]=\left(n_d+(\mu-1)n_e-\mu n_i\right)\frac{d\phi}{d\xi} \quad (19)$$

Using (7), (17) and (18) in (19) and Integrating with respect to ξ, with boundary conditions $\phi\to 0,\left|\frac{d\phi}{d\xi}\right|\to 0$ when $|\xi|\to\infty$, we get

$$\frac{1}{2}\left(\frac{d\phi}{d\xi}\right)^2=\frac{Q'}{6\sqrt{\frac{3\sigma}{Q'}}}\left[\left\{\left(M+\sqrt{\frac{3\sigma}{Q'}}\right)^2+\frac{2\phi}{Q'}\right\}^{\frac{3}{2}}-\left\{\left(M-\sqrt{\frac{3\sigma}{Q'}}\right)^2+\frac{2\phi}{Q'}\right\}^{\frac{3}{2}}+\left(M-\sqrt{\frac{3\sigma}{Q'}}\right)^3-\left(M+\sqrt{\frac{3\sigma}{Q'}}\right)^3\right]$$
$$+\frac{\mu}{6\sqrt{\frac{3\sigma}{\mu}}}\left[\left\{\left(M+\sqrt{\frac{3\sigma}{\mu}}\right)^2-2\phi\right\}^{\frac{3}{2}}-\left\{\left(M-\sqrt{\frac{3\sigma}{\mu}}\right)^2-2\phi\right\}^{\frac{3}{2}}+\left(M-\sqrt{\frac{3\sigma}{\mu}}\right)^3-\left(M+\sqrt{\frac{3\sigma}{\mu}}\right)^3\right]$$
$$+(\mu-1)\left[\left(1+3\beta-3\beta\phi+\beta\phi^2\right)\exp(\phi)-(1+3\beta)\right] \quad (20)$$

The equation (20) is of the form

$$\frac{1}{2}\left(\frac{d\phi}{d\xi}\right)^2+S(\phi)=0$$

where,

$$S(\phi)=\frac{Q'}{6\sqrt{\frac{3\sigma}{Q'}}}\left[\left\{\left(M-\sqrt{\frac{3\sigma}{Q'}}\right)^2+\frac{2\phi}{Q'}\right\}^{\frac{3}{2}}-\left\{\left(M+\sqrt{\frac{3\sigma}{Q'}}\right)^2+\frac{2\phi}{Q'}\right\}^{\frac{3}{2}}+\left(M+\sqrt{\frac{3\sigma}{Q'}}\right)^3-\left(M-\sqrt{\frac{3\sigma}{Q'}}\right)^3\right]$$

$$+\frac{\mu}{6\sqrt{\frac{3\sigma}{\mu}}}\left[\left\{\left(M-\sqrt{\frac{3\sigma}{\mu}}\right)^2-2\phi\right\}^{\frac{3}{2}}-\left\{\left(M+\sqrt{\frac{3\sigma}{\mu}}\right)^2-2\phi\right\}^{\frac{3}{2}}+\left(M+\sqrt{\frac{3\sigma}{\mu}}\right)^3-\left(M-\sqrt{\frac{3\sigma}{\mu}}\right)^3\right]$$

$$+(\mu-1)\left[(1+3\beta)-\left(1+3\beta-3\beta\phi+\beta\phi^2\right)\exp(\phi)\right]$$

The equation (20) is the Sagdeev Potential equation for our plasma model. This shows that the total energy of a moving particle having unit mass with velocity $\frac{d\phi}{d\xi}$ at an instant ξ is preserved during its motion, and so it represents an energy integral. $S(\phi)$ is a pseudopotential, called Sagdeev potential.

Conditions for Existence of Solitary Waves

The existence of solitary wave solution of the equation (20) depends upon the pseudopotential $S(\phi)$, which represents the potential energy of the waves. The conditions are,

(i) $S(\phi)=0$ and $S'(\phi)=0$ at $\phi=0$

(ii) There exists a value ϕ_m of ϕ, such that $S(\phi_m)=0$ and $S(\phi)<0$ for $0<\phi<\phi_m$.

Here, ϕ_m is the maximum or minimum value of ϕ and $|\phi_m|$ is the amplitude of the solitary wave. For different values of the parameters ϕ_m is different. If ϕ_m is positive, the solitary waves are said to be compressive, and for negative ϕ_m the waves are said to be rarefactive.

Solution for Small Amplitude Solitary Waves

The pseudopotential $S(\phi)$ can be expanded as,

$$S(\phi)=A_1\phi^2+A_2\phi^3+A_3\phi^4+A_4\phi^5+..................$$

where,

$$A_1=\frac{1}{4Q'\sqrt{\frac{3\sigma}{Q'}}}\left(a_1^{-1}-b_1^{-1}\right)+\frac{\mu}{4\sqrt{\frac{3\sigma}{\mu}}}\left(a_2^{-1}-b_2^{-1}\right)-\frac{(\mu-1)(1-\beta)}{2}$$

$$A_2=-\frac{1}{12Q'^2\sqrt{\frac{3\sigma}{Q'}}}\left(a_1^{-3}-b_1^{-3}\right)+\frac{\mu}{12\sqrt{\frac{3\sigma}{\mu}}}\left(a_2^{-3}-b_2^{-3}\right)-\frac{\mu-1}{6}$$

$$A_3=\frac{1}{16Q'^3\sqrt{\frac{3\sigma}{Q'}}}\left(a_1^{-5}-b_1^{-5}\right)+\frac{\mu}{16\sqrt{\frac{3\sigma}{\mu}}}\left(a_2^{-5}-b_2^{-5}\right)-\frac{(\mu-1)(1+3\beta)}{24}$$

$$A_4=-\frac{1}{16Q'^4\sqrt{\frac{3\sigma}{Q'}}}\left(a_1^{-7}-b_1^{-7}\right)+\frac{\mu}{16\sqrt{\frac{3\sigma}{\mu}}}\left(a_2^{-7}-b_2^{-7}\right)-\frac{(\mu-1)(1+8\beta)}{120}$$

$$a_1=M-\sqrt{\frac{3\sigma}{Q'}},\ b_1=M+\sqrt{\frac{3\sigma}{Q'}},\ a_2=M-\sqrt{\frac{3\sigma}{\mu}},\ b_2=M+\sqrt{\frac{3\sigma}{\mu}}$$

I. Considering terms upto the third degree of $S(\phi)$, the equation (20) reduces to,

$\left(\frac{d\phi}{d\xi}\right)^2=c_1\phi^2-c_2\phi^3$, where, $c_1=-2A_1$, $c_2=2A_2$

Integrating we get the solution of (20) as,

$$\phi = \frac{c_1}{c_2} \sec h^2 \left(\frac{\sqrt{c_1}}{2} \xi \right)$$

Or, $\phi = \phi_0 \sec h^2 (\Delta \xi)$ (21)

Where, $\phi_0 = \frac{c_1}{c_2}$ and $\Delta = \frac{\sqrt{c_1}}{2}$

This is one solution of the Sagdeev potential equation (20).

II. Again, to obtain a better solution of equation (20), we consider terms upto the fourth degree of $S(\phi)$, so that the equation (20) reduces to,

$\frac{d\phi}{d\xi} = \phi\sqrt{c_1 - c_2\phi - c_3\phi^2}$, where $c_1 = -2A_1, c_2 = 2A_2, c_3 = 2A_3$.

Integrating, we get

$$\phi = \left[\frac{c_2}{2c_1} + \left(\frac{c_2^2}{4c_1^2} + \frac{c_3}{c_1} \right)^{\frac{1}{2}} \cosh\left(\sqrt{c_1}\xi\right) \right]^{-1}$$

(22)

This is another solution of the Sagdeev potential equation (20).

These types of solutions were obtained by Das et.al in 1997 [18-19] in the study of ion-acoustic waves. The solutions (21) and (22) are similar to the solutions of well known korteweg –d Vries (KdV) equation and equation having mixed nonlinearity of KdV and mKdV equations respectively. Hence, they represent solitary wave profiles. The solution (21) represents a solitary wave profile, whose amplitude and width are given by,

$\phi_0 = \frac{c_1}{c_2}$ and $\Delta^{-1} = \frac{2}{\sqrt{c_1}}$ respectively.

The wave profile represented by the solution (22) has the maximum amplitude,

$$\phi_{\max} = \frac{c_2}{2c_1} + \left(\frac{c_2^2}{4c_1^2} + \frac{c_3}{c_1} \right)^{\frac{1}{2}}$$

Thus, the Sagdeev Potential equation (22) admits the solitary wave solution.

RESULTS AND DISCUSSIONS

To investigate the existence of solitary waves for arbitrary amplitude, we plot $S(\phi)$ vs. ϕ, taking the values of the parameters from a possible range. We have observed in figure1, the existence of compressive solitary wave for some fixed vales of the parameters. The small amplitude solitary waves and variation of amplitudes and widths with the parameters are studied by plotting the equation (21) for ϕ vs. ξ.

In figure (2), we have studied the small amplitude solitary waves for three different values of the Mach number $M = 0.68, 0.69, 0.70$, keeping the values of other parameters fixed. It has been observed that, the amplitude and width both are decreasing, when the Mach number is increasing. This implies that, the waves with higher phase speed have lower amplitude and width. But in Chapter 3, we had seen a reverse scenario in case of dust acoustic waves with nonthermal ions.

The effect of the population of nonthermal electrons is studied by considering three different values of $\alpha(= 0.30, 0.40, 0.50)$ with fixed values of the other parameters. In figure 3, it has been observed that, the amplitudes are increasing when α is increasing, but at the same time widths are decreasing. Thus, the solitary waves propagate with higher amplitude with the effect of higher concentration of nonthermal electrons, but in case of width it is found to be reversed.

Another important parameter is the temperature ratio, which is defined as $\sigma = \frac{T_i}{T_e} \left(\text{or } \frac{T_d}{T_e} \right)$, where T_i, T_d, T_e are respectively the temperatures of ions, dust and electrons. . In nonthermal plasma $T_e >> T_i, T_d$, and hence $\sigma < 1$. We have considered three values of $\sigma(= 0.3, 0.4, 0.5)$ and observed that the amplitudes are decreasing when σ is increasing, but the widths are increasing (figure 4). This implies that, when temperatures of ions and dust are increased, the amplitudes of the solitary waves are decreased but widths are increased.

In figure 5, we studied the effect of densities of ions and dusts. The density ratio is defined as $\mu = \frac{n_{i0}}{z_d n_{d0}}$, which is obviously <1 (since dust density is greater than ion density). Considering $\mu = 0.01, 0.02, 0.03$, we have observed that, amplitudes and widths of the solitary waves are increasing, as μ is increasing. That is, soliton amplitude and width both are increased, when the density of ions is increased.

The mass ratio of dust (m_d) and ion (m_i) is defined as $Q' = \frac{m_d}{m_i}$. Since the mass of dust particles is greater than that of ions, $Q' > 1$. We have considered the different values as $Q' = 8, 9, 10$, and observed that amplitudes and widths of the solitons both are decreasing, when Q' is increasing (figure 6). This shows that, when the mass of the dust particles are increased, the amplitude and width of the solitons are decreased.

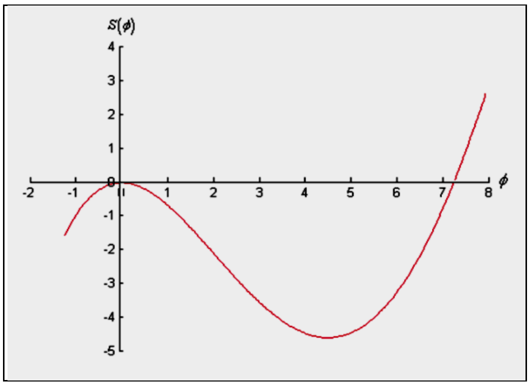

Fig.1: $S(\phi)$ vs. ϕ for $\mu = 0.01, \sigma = 0.3, q = 10, M = 0.68, \alpha = 0.40$

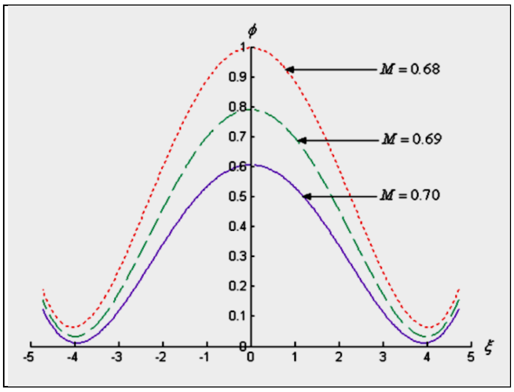

Fig.2: ϕ vs. ξ for different values of $M = 0.68, 0.69, 0.70$ and fixed values $\mu = 0.01, \sigma = 0.3, Q' = 10, \alpha = 0.4$

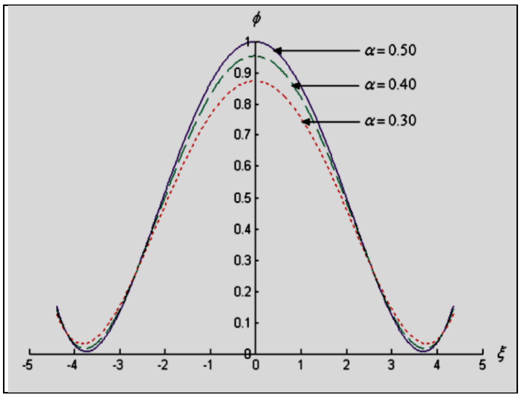

Fig.3: ϕ vs. ξ for different values of $\alpha = 0.30, 0.40, 0.50$ and $\mu = 0.01, \sigma = 0.3, Q' = 10, M = 0.68$

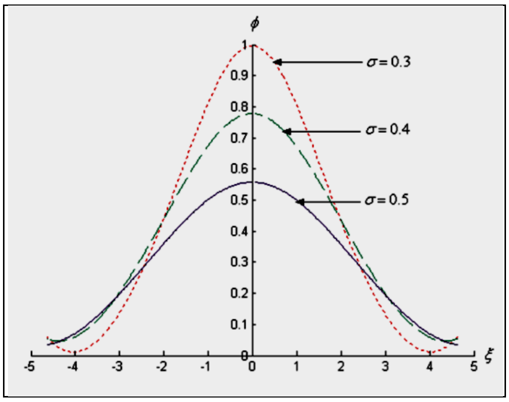

Fig.4: ϕ vs. ξ for different values of $\sigma = 0.3, 0.4, 0.5$ and fixed values $\mu = 0.01, \alpha = 0.40, Q' = 10, M = 0.68$

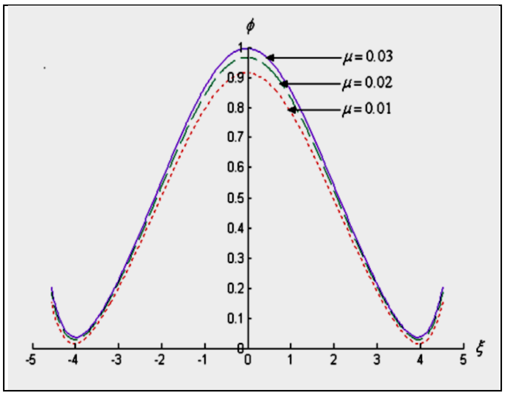

Fig.5: ϕ vs. ξ for different values of $\mu = 0.01,\ 0.02,\ 0.03$ and fixed values $\sigma = 0.3, \alpha = 0.40, Q' = 10, M = 0.68$

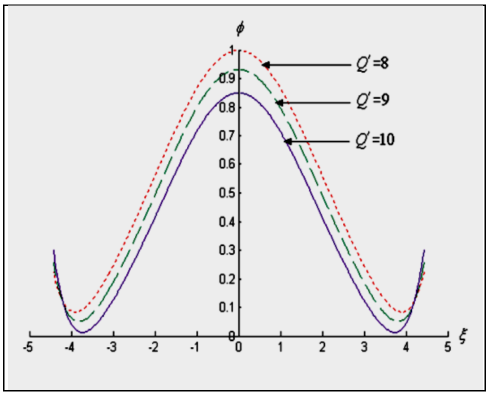

Fig.6: ϕ vs. ξ for different values of $Q' = 8,\ 9,\ 10$ and for fixed values $\sigma = 0.3, \alpha = 0.40, \mu = 0.01, M = 0.68$

CONCLUSIONS

The co-operative phenomena in respect of the collective behavior of the plasma medium under the present model are studied. The nonlinear plasma wave structures in the form of compressive solitary waves are found to exist in plasma as dust ion acoustic solitary wave. The effect of the parameters in amplitude and width are observed with the solution for small amplitude solitary waves. As a future scope of the present work, the different regions of propagation of arbitrary amplitude dust ion acoustic solitary plasma waves under the effect of nonthermal electrons can be earmarked by computing $S(\phi)$ versus ϕ for different values of the parameters. The parameters of importance for such computation are Q', μ, α, M and σ.

REFERENCES

1. Rao NN, Shukla PK, Yu MY. Dust-acoustic waves in dusty plasmas. Planet Space Sci. 1990; 38(4): 543-546
2. Shukla PK, Silin VP. Dust-ion-acoustic waves. Phys Scripta. 1992; 13a: 508
3. Barkan A, Merlino RL, D'angelo N. Laboratory observation of the dust-acoustic wave mode. Phys Plasmas. 1995; 2(10): 3563-3565
4. Nakamura Y, Sarma A.Observation of ion-acoustic solitary waves in a dusty plasma. Phys Plasmas. 2001; 8(9): 3921-3926
5. Samsonov D, Ivlev AV, Quinn RA, Morfill G, Zhdanov S. Dissipative Longitudinal Salitons in a Two-Dimensional Strongly Coupled Complex (Dusty) Plasma. Phys Rev Lett. 2002; 88: 095004
6. Baluku TK, Hellberg MA. Dust acoustic solitons in plasmas with kappa-distributed electrons and ions. Phys Plasmas. 2008; 15: 123705
7. de Angelis U. The physics of dusty plasmas. Phys Scripta. 1992; 45(5): 465-474
8. Langmuir I, Found CG, Dittner AF. A New type of Electric Discharge: The Streamer Discharge. 1924; 60(1557): 392-394
9. Rahman O, Mamun AA. Dust-ion-acoustic waves in dusty plasma with arbitrarily charged dust and vortex-like electron distribution. Phys Plasmas. 2011; 18: 083703
10. Duha SS, Shukla PK, Mamun AA. Nonlinear dust-ion-acoustic waves in a multicomponent plasma with trapped electrons. J Phys. 2011; 77(2): 257-268
11. Shukla PK, Silin VP. Dust ion-acoustic wave. Phys Scripta. 1992; 45(5): 508
12. Bacha M, Tribeche M, Shukla PK. Dust-ion-acoustic solitary waves in a dusty plasma with nonextensive electrons. Phys Rev. 2012; 85(5): 056413
13. Chatterjee P. Nonperturbative Approach to Solitary Waves in Plasmas. Jadavpur University Thesis. 1995
14. Mamun AA, Cairns RA, Shukla PK. Solitary potentials in dusty plasmas. Phys Plasmas. 1996; 3(2): 702-704
15. Sagdeev RZ. Review of Plasma Physics. New York Consultant Bureau. 1966; 4(52)

16. Davis L, Lust R, Schluter A. The Structure of Hydromagnetic Shock Waves. Z Naturforchg. 1958; 13a: 916-936
17. Cairns RA, Mamun AA, Bingham R, Bostrom R, Dendy RO, Naim CMC, Shukla PK. Electrostatic solitary structures in nonthermal plasmas. Geophys Res Lett. 1995; 22(20): 2709-2712
18. Das GC, Dwivedi CB, Talukdar M, Sarma J. A new mathematical approach for shock-wave solution in dusty plasma. Phys Plasmas. 1997; 4(2): 4236-4239
19. Das GC, Sarma J, Talukdar M. Dynamical aspects of various solitary waves and double layers in dusty plasmas. Phys Plasmas. 1998; 5(1): 63-69

How to cite this article: Sarmah B, Devi A, Sarma J. Nonperturbative technique for dust-ion-acoustic waves in dusty plasma with nonthermal electrons. International Journal of Research and Review. 2019; 6(11):153-161.

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