Chapter 1

General Introduction

Plasma physics, in parallel to the other branches of physics, has been studying with its possible application successfully in various contexts. The scientific community has already given a light saying that the plasma study will give a major breakthrough in technological applications. By now enough significant indication has already been found in plasma dynamics and showing a great importance in space and laboratory plasmas as well as in other astrophysical phenomena. The subject thus opens a reach field for research among the scientific community. The term plasma, coined by Langmuir (1929) defines generally any state of matter with sufficient numbers of charged particles under electromagnetic force (EMF) but it is exceptionally a unique state of matter. The plasma could be studied in various ways e.g. by microscopic as well as by macroscopic approaches. In plasma, the wave dynamics has taken the key position as it always keeps a closed relation between the theory and experiments as well as with the observations made by satellites and by other spacecrafts in astrophysical plasmas. In the beginning, the plasma model was simplified by consisting electrons and singly charged ions and studied the wave phenomena through the linear theory. But plasma invariably consists of multiple species of different charges and thereby many observations were made to frame the problems in multicomponent plasmas in relation to their existences in laboratory and space plasmas. Based on the linear perturbation technique, many of the results, derived by the augmentation of waves, have shown a potential interest to employ in space and laboratory plasmas. In this regard, the pioneer works of Hartree-Appleton [Hartree (1931), Appleton (1932)] should be
quoted whose application has been found to boost the diagnose of plasmas. Later on, this linear theory was found insufficient to describe many of the plasma properties and thus the attention follows towards the interaction of higher order effect in the dynamics. This leads to develop the nonlinear wave theory for finding the new observations. Probably the nonlinear wave phenomena herald from the heuristic observation on the solitary wave in water by Russell (1838) in 1834. Later, many researchers observed theoretically and experimentally the formation and propagation of solitary waves in various branches of physics and applied mathematics. The simplest form of nonlinear wave equation, known as Korteweg-de Vries (K-dV) equation, has been derived first in fluid mechanics [Korteweg and de Vries (1895)] and took a long way to its finding in plasma dynamics. The nonlinear wave equation showing the formation of solitary wave resulted as an interaction of nonlinearity with weak dispersive effect of the medium. The steady-state solution of K-dV wave equation describes the hump shaped profile, as a \text{sech}(-) function, called solitary wave which was exactly observed in water wave by Russell (1834). When the effect of dispersion is weak, the solitons are generally governed by the usual K-dV equation (or any of its generalizations) are known as K-dV solitons. The concept of soliton has now become ubiquitous in modern nonlinear science and indeed can be found in various branches of physics and mathematics. Generally the soliton can be defined as stationary, localized nonlinear wave which arises due to nonlinearity, balanced by dispersiveness of the medium. Many of the nonlinear wave equations by now have taken the leading role to show the soliton dynamics, while main choice on the existence of soliton starts its milestone from the K-dV equation. However, the concept of soliton was established from the pioneering works of Zabusky and Kruskal (1965), who made the computer study for K-dV solitary wave. In the same decade these results were analytically confirmed by the works of Gardner et al. (1967) by using a general method known as inverse scattering technique to solve the nonlinear K-dV equation. Thereafter, many techniques, such as Bäcklund transform, Lax pair, Hirota's method, Lie group algebra, Painlevé analysis, traveling wave solution method and tanh-method etc., have been developed parallelly for the nonlinear wave equations. The study of nonlinear phenomena in plasma dynamics have taken more than half a century to reproduce the interesting and exciting description on soliton formation and its propagation through the K-dV equation. Washimi and
Taniuti (1966), were probably the first to give a concise approach known as reductive perturbation technique for deriving the K-dV equation for studying the ion-acoustic solitary waves in plasma. In the derivation of K-dV equation by using perturbation method the approximation of small amplitude wave concept has been taken in plasma. In order to study the plasma-acoustic waves of arbitrary amplitude derived by nonperturbative approach known as Sagdeev (1966) potential analysis. However, the method was first discussed by Davis et al. (1958) in fluid dynamics and then used extensively in plasma dynamics and goes with the name of Sagdeev potential equation. In the study of nonlinear phenomena in plasma most of the earlier observations were limited to a simple plasma consists of simply electrons and ions [Washimi and Taniuti (1966)]. The results of solitary wave phenomena in plasma were confirmed experimentally by Ikezi and his collaborators [Ikezi et al. (1970), Ikezi (1973)]. In general plasma occurs with multiple charges consisting of multiple ionic species of different kinds or multitemperature electrons. The study, based on linear theory, on the characteristic behaviour of low frequency electromagnetic waves in multicomponent plasma has shown new observations especially in lower ionosphere that too have shown the effective interaction of negative ions in plasma waves.

The low frequency wave later found to be of greater interest of using as a diagnostic technique [Gurnett et al. (1965), Smith (1965), Teichmann (1966), Das and Uberoi (1972)] in the lower ionosphere and concludes that the diagnosis procedure will have serious error if a proper account of the negative ions are not taken in to consideration in plasma dynamics. The existence of negative ions in plasma has shown some exciting observations in soliton which in turn becomes a turning point in studying the nonlinear solitary waves in plasmas [Das (1975, 1976, 1977a, 1977b, 1979), Das and Tagare (1975)]. It is observed that the initial phase velocity in simple plasma equals to unity whereas in multicomponent plasma the phase velocity depends functionally on plasma parameters and consequently the salient features of the soliton differ from model to model. The study resulted with the existence of compressive and rarefactive solitary wave arises due to the interaction of negative ions in plasmas. From the observations of Das and his co-workers [Das (1975, 1976, 1977a, 1977b, 1979), Das and Tagare (1975) and Singh (1991)] it is found that there will be a critical concentration at which the nonlinearity in the K-dV equation disappears and consequently the soliton observations as well. Moreover, in the neighborhood
of this critical density, the amplitude of the ion-acoustic wave become infinitely large and gives an indication of nonapplicability of reductive perturbation technique. Das(1975) has shown that the reductive perturbation technique is effectively applicable in plasma even though the negative ions introduces such critical ion-concentration. In this process, the exciting observations yields by the interaction of negative ions [Ludwing et al.(1984), Nakamura and Tsykabayashi(1984), Nakamura et al.(1985), Nakamura (1987), Cooney et al.(1991), Williams et al.(1992), Yi et al.(1996)] have explained, in laboratory too, the occurrences of the new features in space and astrophysical plasmas. The observations in plasmas with negative ions have been found to be the new achievement in plasma-acoustic waves [Lonngren(1983), Watanabe(1984)]. Later, it has been confirmed that the presence of negative ions causes the formation of various soliton nature in contrast to that derived in simple plasma and encourages to relate them in experiments as well as in space plasmas. Parallel works have been carried out in another form of multicomponent plasma having multitemperature electrons generated by the trapping of electrons in the potential well formed in plasma. Many observations were made theoretically [Schamel (1972, 1973), Maxon et al.(1974), Maxon (1976), Tran and Means(1976), Das (1976), Goswami and Buti (1976), Singh and Das(1989), Das and Sen(1994)] as well as experimentally by Jones et al. (1975), Nishida and Nagasawa(1986) in such plasma configurations and highlighted the new features on nonlinear waves. Further study have been extended in plasma embedded with an applied magnetic field [Roychoudhury and Bhattacharyya(1989), Nejoh(1987), Bharuthram and Shukla(1992), Das and Sen(1991)] and related the observations in space plasmas [Torven(1981), Raadu(1989)].

There might be many other observations which might deserve merit for the scientific contributions to the nonlinear plasma wave dynamics, but we are very much reluctant to cite all these with their descriptions in the present thesis.

Recently, the dusty plasma is growing as one of the thrust areas to know its interaction in the nonlinear phenomena of plasma-acoustic waves. The dust particles are ubiquitous component in plasma throughout the universe and represent much of the solid matter of having micron size dust grain with masses of order $\sim 10^6 - 10^8$ proton. These
dust grains gets highly charged [Spitzer(1941)] with respect to normal electric charges ($Q_d \sim 10^3 e - 10^4 e$) due to the collection of electrons and ions from the surrounding plasma, sputtering by energetic ions, photoelectron emission by ultraviolet radiation, secondary electron emission [Drain and Salpeter(1979)] etc. The process are important, of course, depending on the plasma and radiative environment in which the grains are immersed. However, the grain can be regarded as being 'isolated' or dust-in-plasma, which is conditionally defined as $a \ll \lambda_D < d$, where with usual notation $a$ is the dust grain size, $d$ is the intergrain distance, $\lambda_D$ is the Debye distance. On the other hand, collective effect of the charged dust become important when dust grain in a plasma are 'closely packed' i.e when the average distance of a grain from its nearest particle become smaller than the plasma Debye length, which can be define as $a \ll d < \lambda_D$ and this case is generally referred to as a 'dusty plasma' [Whipple(1981), Goertz and Ip(1984), Whipple et al.(1985), Goertz(1989), Mendis and Rosenberg (1992), D'Angelo(1994), Verheest(1996)]. This dusty plasma is very common throughout the universe, as well as in some experiments. Interest on dusty plasma has been discussed in various space environments; such as radial structure of Saturn rings as observed by Voyager spacecraft, Jupiter rings, the narrow ring of Uranus, the rings of Neptune [Goertz(1989)] as well as in lower ionosphere, magnetosphere and in other astrophysical plasmas. Dusty plasma are also present in many laboratory devices and industrial processes such as plasma processing, plasma etching, magnetohydrodynamic power generation, rocket exhaust, fusion devices, plasma aided manufacturing of semiconductor devices, [Whipple(1981), Goertz(1989), Melandso and Havnes(1991), de Anglies (1992), Northrop(1992), Mendies and Rosenberg(1992)]. Again charging of dust grains is essentially a very important factor in the dynamics of the dusty plasma. The main interest in space dust was to calculate its single particle orbits which can be involved as its charge vary with the environment conditions and its own speed [Drain and Salpeter(1979), Goertz(1989)]. The basic charging equation for the variation of dust charged $Q_d$ particle immersed in a plasma is given by

$$\frac{dQ_d}{dt} = I_e + I_i \quad (1.1)$$
where

\[ I_e = -\pi a^2 e \left( \frac{8k_B T_e}{\pi m_e} \right) \frac{f_e}{\phi^{k_B T_e}} \]  \hspace{1cm} (1.2)

\[ I_i = \pi a^2 e \left( \frac{8k_B T_i}{\pi m_i} \right) n_i \left( 1 - \frac{e\phi}{k_B T_i} \right) \]  \hspace{1cm} (1.3)

with usual notations [Spitzer(1978), Drain and Salpeter(1979)]. The presence of these highly charged and massive dust particles significantly influence the collective properties of the plasma phenomena and shows importance in plasma dynamics [deAngelis et al.(1989), Rao et al.(1990)]. The primary emphasis has been given on the modification of collective properties on soliton arising due to the interaction of dust particles. The charge of the dust particles taken to be constant and then the analysis become analogous to the works on multicomponent plasma but, as will seen, some new features and could be interested to look for it. Based on such concept the observations on various plasma-acoustic modes are presented in Part-II.

1.1 Mathematical development for nonlinear wave propagation in plasmas

In order to study the soliton dynamics along with other plasma modes, two different theoretical approaches known as reductive perturbation approach developed by Washimi and Taniuti(1966) and quasipotential analysis or Sagdeev potential analysis by Sagdeev(1966), are used for studying nonlinear ion-acoustic waves.

1.1.1 Reductive perturbation approach

The prime objective is to reduce the system of plasma equations into a solvable nonlinear wave equation and has been facilitated to study the various solitary waves and their propagation in plasmas. The study of the nonlinear waves is based on the reductive perturbation technique to derive the K-dV equation for the unidirectional propagation or propagation in space as well. Following Washimi and Taniuti(1966), Davidson(1972) and
Das(1975), basic equations governing the plasma dynamics are written in the following normalized form [Equations for a two component plasma] as: The equations for ions,

\[ \frac{\partial n}{\partial t} + \nabla \cdot (n v) = 0 \]  \hspace{1cm} (1.4)

\[ \frac{\partial v}{\partial t} + (v \cdot \nabla)v = -\nabla \phi \]  \hspace{1cm} (1.5)

Supplemented by the Poisson equation:

\[ \nabla^2 \phi = n_e - n \]  \hspace{1cm} (1.6)

Basic equations for electrons are the same, but equations are simplified by neglecting the electron inertia along with \( T_e \ll T_e \). Due to which it enables to derive the Boltzmann relation as [Singh(1991)]:

\[ n_e = \exp(\phi) \]  \hspace{1cm} (1.7)

All the plasma parameters (\( n, v, \phi \)) and the space-time variable are normalized in the following form \( n = \frac{n}{n_0}, n_e = \frac{n_e}{n_0}, v = v_l(k_B T_e)^{-\frac{1}{2}} \) and \( \phi = \phi\left(\frac{k_B T_e}{m_i}\right)^{-\frac{1}{2}} \), \( x = x'\left(\frac{k_B T_e}{\xi n_0 e^2}\right)^{-\frac{1}{2}}, t = t'\left(\frac{\xi n_0 e^2}{m_i}\right)^{\frac{1}{2}} \). \( v_l \) is the velocity of the ions having mass \( m_i \) and number density \( n \) with temperature \( T_i \). \( n_e \) and \( T_e \) represent the number density and temperature of electrons. \( n_0 \) is the number density of ions and electrons at initial state. \( \phi \) is electrostatic potential and \( k_B \) is the Boltzmann constant. All other symbols have their usual meaning.

To get the desired nonlinear wave equation from the governing equations, we further assumed in order to employ reductive perturbative technique, a small but finite amplitude wave analysis. The dispersion relation for the low frequency wave found a scaling for independent variables through the new stretched coordinates. The linear dispersion relation for ion-acoustic wave, based on linear perturbation technique [Jeffery and Kawahara(1982)] derived from the equations (1.4)-(1.7) as:

\[ \omega^2 = k^2(1 + k^2)^{-1} \]  \hspace{1cm} (1.8)

where \( k \) is the wave number and \( \omega \) is the wave frequency. In the study of nonlinear dispersive waves, Gardner and Morikawa(1960) introduce the scale transformation in the
following form:
\[ \xi = \epsilon^\alpha (x - \lambda t), \quad \tau = \epsilon^\beta t \]  
(1.9)

Where \( \lambda \) is the unknown phase velocity of the ion-acoustic wave. This scale transformation, known as Gardner-Morikawa transformation, can derive from linear dispersion relation. Likewise there are various stretching for space-time coordinate depends on \( \alpha \) and \( \beta \). Thereafter different stretching coordinates are used to generate a wide class of nonlinear wave equations and correspondingly the plasma parameters are perturbed as:
\[ p = \sum \epsilon^\alpha p^{(\alpha)} \text{ where } p = (n, v, \phi); \]  
(1.10)

for the completeness of reductive perturbation technique. Now the reductive perturbation procedure has been used in equations (1.4)-(1.7) and then balancing the leading order of \( \epsilon \) i.e. at it, lowest \( O(\epsilon) \), gives as [here we have taken \( \alpha = \frac{1}{2} \) and \( \beta = \frac{3}{2} \)];

\[ n^{(1)} = v^{(1)} = \phi^{(1)} \]  
(1.11)

From which the phase velocity is derives as: \( \lambda = 1 \)

The next higher order in \( \epsilon \) derives the following differential equations
\[ \frac{\partial n^{(1)}}{\partial \tau} - \frac{\partial n^{(2)}}{\partial \xi} + \frac{\partial n^{(1)} v^{(1)}}{\partial \xi} + \frac{\partial v^{(2)}}{\partial \xi} = 0 \]  
(1.12)
\[ \frac{\partial v^{(1)}}{\partial \tau} - \frac{\partial v^{(2)}}{\partial \xi} + \frac{v^{(1)} \partial v^{(1)}}{\partial \xi} = \frac{\partial \phi^{(2)}}{\partial \xi} = 0 \]  
(1.13)
\[ \frac{\partial^2 \phi^{(1)}}{\partial \xi^2} = \phi^{(2)} + \frac{1}{2} (\phi^{(1)})^2 - n^{(2)} \]  
(1.14)

The elimination of \( n^{(2)} \) and \( v^{(2)} \) from the first two equations and then using them in third equation together with the results of lowest \( O(\epsilon) \), derives the desired K-dV equation as:
\[ \frac{\partial \phi^{(1)}}{\partial \tau} + A \frac{\partial \phi^{(1)}}{\partial \xi} + B \frac{\partial^3 \phi^{(1)}}{\partial \xi^3} = 0 \]  
(1.15)

with \( A = 1 \) and \( B = \frac{3}{2} \)

This is the well known nonlinear wave equation, known as Korteweg-de Vries(K-dV)
equation. Now the steady-state solution of the K-dV equation [Davidson(1972), Das(1975)]
derives the wave profile as:

\[ \phi^{(1)} = \frac{3U}{A} \text{sech}^2 \left( \frac{\chi}{\delta} \right) \quad \text{with} \quad \delta = \sqrt{\frac{4B}{U}} \] (1.16)

where the transformation \( \chi = \xi - Ut \) has been used.

However, the ion-acoustic wave in space plasmas the K-dV equation could be derive in
multidimensional space and called later as Kadomtsev-Petviashvili(K-P) or Zakharov-
Kuznetsov(Z-K) equation. The stretching coordinates in this case are defined as:

\[ \xi = \epsilon^{\frac{1}{3}}(x - \lambda t), \quad \eta = \epsilon y, \quad \zeta = \epsilon z, \quad \tau = \epsilon^{\frac{1}{3}} t \] (1.17)

and corresponding perturbation of the plasma parameters are:

\[ p = \sum \epsilon^\alpha p^{(\alpha)} \quad \text{with} \quad p = (n, \; v_x, \; \epsilon^{\frac{1}{3}} v_y, \; \epsilon^{\frac{1}{3}} v_z, \; \phi) \] (1.18)

Using the stretching coordinates and perturbation scheme, the set of basic equations, with
the simple mathematical simplification drives the K-P equation [Sen(1993)] as:

\[ \frac{\partial}{\partial \xi} \left[ \frac{\partial \phi^{(1)}}{\partial \tau} + A \phi^{(1)} \frac{\partial \phi^{(1)}}{\partial \xi} + B \frac{\partial^2 \phi^{(1)}}{\partial \xi^3} \right] + D \left[ \frac{\partial^2 \phi^{(1)}}{\partial \eta^2} + \frac{\partial^2 \phi^{(1)}}{\partial \xi^2} \right] = 0 \] (1.19)

In the similar way the Z-K equation is derived as:

\[ \frac{\partial \phi^{(1)}}{\partial \tau} + A \phi^{(1)} \frac{\partial \phi^{(1)}}{\partial \zeta} + B \frac{\partial^3 \phi^{(1)}}{\partial \xi^3} + D \frac{\partial^2 \phi^{(1)}}{\partial \zeta^2} + \frac{\partial^2 \phi^{(1)}}{\partial \eta^2} = 0 \] (1.20)

where the stretched coordinates and the expansion [Jeffery and Kakutani(1972)] are used
as:
\[ \xi = \epsilon^{\frac{1}{2}} x, \quad \eta = \epsilon^{\frac{1}{2}} y, \quad \zeta = \epsilon^{\frac{1}{2}} (z - \lambda t), \quad \tau = \epsilon^{\frac{3}{2}} t \quad (1.21) \]

and

\[ p = \sum \epsilon^a p^{(\alpha)} \quad \text{with} \quad p = (u, \quad \epsilon^{\frac{1}{2}} v_x, \quad \epsilon^{\frac{1}{2}} v_y, \quad v_{iz}, \phi) \quad (1.22) \]

Our aim, is to study in different plasma configurations, the solution of wave equations and their properties.

### 1.1.2 Nonperturbative approach

The outline of the nonperturbative approach to derive the Sagdeev potential equation has been discussed and the analysis derives a wave equation of having an arbitrary amplitude. The procedure is based on the assumption that all the plasma parameters depends functionally \( \xi = x - Mt \) due to which the governing equations are reduced to a set of ordinary differential equations. The elimination of the parameters e. g. \( n \) and \( v \) derives the Sagdeev potential equation as :

\[
\frac{1}{2} \left( \frac{d\phi}{d\xi} \right)^2 + V(\phi) = 0
\]

where the Sagdeev potential \( V(\phi) = 1 - \exp(\phi) + M^2 \left[ 1 - \left( 1 - \frac{2\phi}{M^2} \right)^{\frac{1}{2}} \right] \)

This equation indicates as analog particle motion observed first by Davis et al. (1958) in fluid dynamics and later used extensively by Sagdeev (1966) in plasma and goes with the name of Sagdeev potential equation.

The necessary boundary conditions required to derive the solitary wave profile are

(i) \( \left( \frac{dV(\phi)}{d\phi} \right)_{\phi=0} < 0 \)

(ii) There exist a nonzero \( \phi_m \), the maximum (or minimum) of \( \phi \), at which \( V(\phi_m) = 0 \) and \( V(\phi) \) must be negative in the region \((0, \phi_m)\).
Corresponding shape of the soliton derives as:

$$\pm \xi = \int_a^\phi \frac{d\phi}{\sqrt{-2V(\phi)}}$$  \hspace{1cm} (1.24)

Again it is worthy to mention that the small amplitude wave approximation employed in Sagdeev potential equation could derive the K-dV solitons [Watanabe(1984), Das and Singh(1991)]. We again developed a new approach for solving the nonlinear wave equation for studying the soliton propagation and relate to the observations with actual phenomena.

Now we are going to present our observations in two different parts: Part-I deals the study of the nonlinear ion-acoustic wave phenomena in generalized multicomponent plasmas while the Part-II discuss the evolution of solitons and other related modes in dusty plasma.

Chapter-2 (in Part-I) deals with the nonlinear wave dynamics in plasma consisting of cold ions with multitemperature electrons. To derive the Sagdeev potential equation, the quasipotential analysis has been adopted to the set of basic governing equations. The main attention has been given to the formation of solitary wave and its propagation in plasma. Further it has shown the existence of double layers as well as spiky and explosive solitary modes arisen due to the presence of multitemperature electrons expected in space and laboratory plasmas. The study has been furthered with the effect of different order of nonlinearity to the Sagdeev potential equation and resulted to describe some other progressive modes of new kinds and could be an advanced knowledge for space and laboratory plasmas.

In continuation to the works in chapter-2, the further investigation, in chapter-3, has been done in plasma dynamics in multidimensional space and the theoretical development augmented through the K-P equation. A new formalism has been employed to the K-P equation to get the nonlinear structure of the solitons in plasma. The approach highlights other features of the solitary waves; some of which are found to be interesting in laboratory and space plasmas. Further, the method has proven its strength to the evolution of soli-
ton showing the collapse or explosion due to the interaction of multitemperature electrons.

Chapter-4, deals another multicomponent plasma model consisting of different kind of ionic species in relation to its existence in lower ionosphere, magnetosphere and other surrounding atmosphere as well as in various laboratory plasmas. After deriving the K-P equation, the new approach called as tanh-method, has been employed to find the soliton dynamics. Though the plasma model is known to be simple but we have shown distinctly the evolution of solitary waves along with their compressive and rarefactive nature as similar to those described earlier. Further it has been shown that the different order of nonlinear effect exhibits the shock-like structure in solitary waves which arises due to the interaction of negative ions in plasma.

In continuation to the earlier plasma models described in chapter-2 to 4, chapter-5 deals a generalized multicomponent plasma consisting of different ionic species and derives the overall features of solitons and furthered other related phenomena. However, the approach will be different from the usual reductive perturbation technique and Sagdeev potential analysis. The multidimensional Sagdeev potential equation is derived in multicomponent plasma in relation to the space plasma to know the plasma-acoustic waves. The complete nonlinear wave equation shows the variation of Sagdeev potential equation from which the nature of plasma-acoustic waves are studied. The study on multidimensional Sagdeev potential could exhibit the condition on the formation of soliton and its propagation and successfully yielded the results what exactly observed from the K-P equation. Further in course of studying the nonlinear phenomena of plasma-acoustic waves, Duffing equation has been derived. The Duffing equation thence highlights the possibility in getting the stable soliton solution in the multicomponent plasma.

All the observations on nonlinear wave phenomena so far made in the unmagnetized plasma. In chapter-6, the study on soliton dynamics has been extend in a magnetized plasma. The nonlinear wave equation in multicomponent plasma has been derived to a form which is different from K-dV and K-P equation known as Zakharov-Kuznetsov(Z-K) equation. The main emphasis has been given to employing the hyperbolic-type method.
for finding the soliton features moreover the method becomes unsuccessful, an alternate method has been developed to yield the soliton propagation. The features of the nonlinear plasma-acoustic waves, which depends on the plasma composition, discuss the coexistence of compressive and rarefactive solitary waves. Later, allowing for the higher order nonlinearity in the dynamics, we highlight further the different solitary waves along with double layers. The theoretical observations revealed many other soliton like structures as similar to the dip and hump solitons observed by the Freja Scientific Satellite as well as the collapse solitons expected in the propagation of solar flares and in the interplanetary space plasmas.

Recently, a new focus has been to endeavor to disentangle salient features of nonlinear waves in plasma contaminated by dust charged and grains encountered very often in many plasma media such as in space and laboratory plasmas. Part II of the thesis deals with the works on dusty plasma and are presented in the following chapters.

In chapter-7, the Sagdeev potential equation has been derived by using the pseudopotential analysis to study the soliton dynamics in dusty plasma. The Sagdeev potential equation describes the rarefactive soliton propagation controlled by the dust charged grains. The higher order nonlinearity, with the controlling of dust charged composition, expects, in certain region, the coexisting of double layers or shock like wave along with other various solitary waves known as spiky and explosive modes.

In continuation of the work on dusty plasma, we further extend in chapter-8, our observations to know the interaction of multitemperature electrons. Employing the pseudopotential analysis, the Sagdeev potential equation has been derived in a multicomponent plasma. The multicomponent plasma consisting of free and trapped electrons and the plasma contaminated by the constant dust charged grains, formed by the attachment of electrons to finite size of dust particles. The Sagdeev potential equation, at a small amplitude approximation, lead the evolution of solitary wave propagation in dusty plasma. It has been shown that the ordering of the nonisothermality in the dusty plasma shown its unique role. In the case of plasma with first order nonisothermality, the simple wave.
solution technique derives the compressive solitary wave propagation. For further higher order nonisothermality the method might fails to solve the Sagdeev potential equation and thus an alternate method is used to reveal the coexistence of compressive and rarefactive solitary waves. In addition, for certain plasma parameters, the solitary wave disappear and a double layer is expected. Again with better approximation in the Sagdeev potential equation, more features of solitary waves such as spiky and explosive modes along with double layers are also highlighted.

Chapter-9 deals nothing but further extension for new findings through the derivation of the Sagdeev potential equation. The new formalism known as tanh-method applied to the nonlinear wave equation and evaluates various solitary waves. Overall, the observations expect to be interesting as an advanced theoretical knowledge to relate such in laboratory and space plasmas.

To know the effect of an applied magnetic field, the observation remodelled in multidimensional space plasma. Again we proposed a sech-method or to say hyperbolic method to study the soliton propagation from the Sagdeev potential equation presented in chapter-10.
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