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THEORETICAL INVESTIGATION OF ELECTROSTATIC AND ELECTROMAGNETIC WAVE PROPAGATION AND INSTABILITIES IN DUSTY PLASMA WITH DUST CHARGE FLUCTUATIONS

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ABSTRACT

Astrophysical dust occurs in many circumstances, like interstellar and circumstellar media, and between and around planets and comets. Typical Solar System applications include planetary rings, asteroid zones, cometary comae and tails, and regions of Earth's lower magnetosphere. Dust grains immersed in ambient plasmas are electrically charged by various processes and interact with electromagnetic fields. Intriguing phenomena observed in the 1980s by Voyager cameras and attributed to charged dust are radial spokes in the B-ring and braids in the F-ring of Saturn. Collective effects become important when the dust intergrain distance is smaller than the plasma Debye length, and start from observations that micron-sized dust grains can have very high negative charges and in proportion even higher masses. Characteristic dust frequencies are considerably smaller than corresponding electron or ion quantities, giving rise to new low-frequency eigenmodes, which could explain some of the low-frequency noise in space and astrophysical plasmas. Repelling electrostatic forces between charged dust grains prevent planetary rings from collapsing to very thin sheets, and oscillations in transverse ring thickness give rise to resonant phenomena, held responsible for gaps in the rings of Jupiter and Saturn. Further features are connected with fluctuating dust charges, which imply highly nontrivial source and/or sink terms in the description, and those in turn lead to new electrostatic and electromagnetic instabilities. Many different papers are reviewed which discuss waves and instabilities in dusty space plasmas, both with fixed and variable dust charges, at the linear level and, at the nonlinear level, involving double layers, solitons, vortices and other waves. These studies are at present far ahead of what observations can corroborate, a situation not likely to change soon due to the paucity of coming solar system missions concerned with planetary or cometary phenomena.

KEYWORDS: ASTROPHYSICAL, THIN SHEETS, CORROBORATE, FREQUENCY, PLASMAS

1. INTRODUCTION

The linear propagation of the ion-acoustic waves (IAWs) in a dusty plasma consisting of Boltzmann-distributed electrons and ions, mobile charge fluctuating negative dust and charge fluctuating stationary negative dust has been theoretically investigated. It has been shown that the electron charge fluctuation is a source of dissipation, and is responsible for forming IA shock waves in such a dusty plasma. The basic features of the IA shock waves have been identified in this investigation which could be useful in understanding the properties of localized space dusty plasmas. It has been proposed to design a new laboratory experiment, which will be able to identify the basic features of the ion-acoustic shock waves predicted in this theoretical investigation.

The wave propagation in plasmas has received much attention in recent years because of its vital role in understanding different types of collective processes in space environments, namely, lower and upper mesosphere, cometary tails, planetary rings, planetary magnetosphere, interplanetary spaces, interstellar media, etc. [1]-[6]. The dusty plasmas have also noticeable applications in laboratory devices [7]-[10]. The consideration of charge grains in plasmas does not only modify the existing plasma wave spectra [11]-[13], but also introduces a number of novel eigenmodes, such as the ion-acoustic (IA) waves, the lower-hybrid (LH) waves, the lattice waves, etc [14]-[18]. Most of the studies in dusty plasmas have been confined in considering the dust as negatively charged grains in addition to electrons and positively charged ions as the plasma species [4]-[6], [19]-[24]. It has been found that there are some plasma systems, particularly in space plasma environments, namely, cometary tails [1]-[3], [25], [26], upper mesosphere [27], Jupiter's magnetosphere [28], etc. where positively charged dust grains play significant roles. There are three mechanisms by which the dust grains in the plasma systems mentioned above can be positively charged. These mechanisms are the following:

photoemission in the presence of a flux of ultraviolet (UV) photons; (ii) thermionic emission induced by radiative heating; and (iii) secondary emission of electrons from the surface of the dust grains. In this paper, we have considered a dusty plasma containing mobile charge fluctuating negative dust, charge fluctuating stationary negative dust, Boltzmann-distributed electrons, and ions, and have studied the linear propagation of DA waves.

2. REVIEW OF LITERATURE

The physics and chemistry of dusty plasmas: A laboratory and theoretical investigation NASA Technical Reports Server (NTRS) Whipple, E. C. 1986-01-01

Theoretical work on dusty plasmas was conducted in three areas: collective effects in a dusty plasma, the role of dusty plasmas in cometary atmospheres, and the role of dusty plasmas in planetary atmospheres (particularly in the ring systems of the giant planets). Laboratory investigations consisted of studies of dust/plasma interactions and stimulated molecular excitation and infrared emission by charged dust grains. Also included is a list of current publications.

Self-similar expansion of adiabatic electronegative dusty plasma NASA Astrophysics Data System (ADS)Shahmansouri, M.; Bemooni, A.; Mamun, A. A. 2017-12-01

The self-similar expansion of an adiabatic electronegative dusty plasma (consisting of inertialess adiabatic electrons, inertialess adiabatic ions and inertial adiabatic negatively charged dust fluids) is theoretically investigated by employing the self-similar approach. It is found that the effects of the plasma adiabaticity (represented by the adiabatic index) and dusty plasma parameters (determined by dust temperature and initial dust population) significantly modify the nature of the plasma expansion. The implications of our results are expected to play an important role in understanding the physics of the expansion of space and laboratory electronegative dusty plasmas.

A survey of dusty plasma physics NASA Astrophysics Data System (ADS) Shukla, P. K. 2001-05-01

Two omnipresent ingredients of the Universe are plasmas and charged dust. The interplay between these two has opened up a new and fascinating research area, that of dusty plasmas, which are ubiquitous in different parts of our solar system, namely planetary rings, circumsolar dust rings, the interplanetary medium, cometary comae and tails, as well as in interstellar molecular clouds, etc. Dusty plasmas also occur in noctilucent clouds in the arctic troposphere and mesosphere, cloud-to-ground lightening in thunderstorms containing smoke-contaminated air over the United States, in the flame of a humble candle, as well as in microelectronic processing devices, in low-temperature laboratory discharges, and in tokamaks. Dusty plasma physics has appeared as one of the most rapidly growing fields of science, besides the field of the Bose-Einstein condensate, as demonstrated by the number of published papers in scientific journals and conference proceedings. In fact, it is a truly interdisciplinary science because it has many potential applications in astrophysics (viz. in understanding the formation of dust clusters and structures, instabilities of interstellar molecular clouds and star formation, decoupling of magnetic fields from plasmas, etc.) as well as in the planetary magnetospheres of our solar system [viz. Saturn (particularly, the physics of spokes and braids in the B and F rings), Jupiter, Uranus, Neptune, and Mars] and in strongly coupled laboratory dusty plasmas. Since a dusty plasma system involves the charging and dynamics of massive charged dust grains, it can be characterized as a complex plasma system providing new physics insights. In this paper, the basic physics of dusty plasmas as well as numerous collective processes are discussed. The focus will be on theoretical and experimental observations of charging processes, waves and instabilities, associated forces, the dynamics of rotating and elongated dust grains, and some nonlinear structures (such as dust ion-acoustic shocks, Mach cones, dust voids, vortices, etc). The latter are typical in astrophysical settings and in several laboratory experiments. It appears that collective processes in a complex dusty plasma would have excellent future perspectives in the twenty-first century, because they have not only potential applications in interplanetary space environments, or in understanding the physics of our universe, but also in advancing our scientific knowledge in multidisciplinary areas of science.

ICPP: Introduction to Dusty Plasma Physics NASA Astrophysics Data System (ADS) Kant Shukla, Padma 2000-10-01

Two omnipresent ingredients of the Universe are plasmas and charged dust. The interplay between these two has opened up a new and fascinating research area, that of dusty plasmas, which are ubiquitous in in different parts of our solar system, namely planetary rings, circumsolar dust rings, interplanetary medium, cometary comae and tails, interstellar molecular clouds, etc. Dusty plasmas also occur in noctilucent clouds in the arctic troposphere and mesosphere, cloud-to-ground lightening in thunderstorms containing smoke-contaminated air over the US, in the flame of humble candle, as well as in microelectronics and in low-temperature laboratory discharges. In the latter, charged dust grains are strongly correlated. Dusty plasma physics has appeared as one of the most rapidly growing field of science, besides the field of the Bose-Einstein condensate, as demonstrated by the number of published papers in scientific journals and conference proceedings. In fact, it is a truly interdisciplinary science because it has many potential applications in astrophysics (viz. in understanding the formation of dust clusters and structures, instabilities of interstellar molecular clouds and star formation, decoupling of magnetic fields from plasmas, etc.) as well as in the planetary magnetospheres of our solar system [viz. the Saturn (particularly, the physics of spokes and braids in B and F rings), Jupiter, Uranus, Neptune, and Mars] and in strongly coupled laboratory dusty plasmas. Since dusty plasma system involves the charging and the dynamics of extremely massive charged dust particulates, it can be characterized as a complex plasma system with new physics insights. In this talk, I shall describe the basic physics of dusty plasmas and present the status of numerous collective processes that are relevant to space research and laboratory experiments. The focus will be on theoretical and experimental observations of novel waves and instabilities, various forces, and some nonlinear structures (such as dust ion-acoustic shocks, Mach cones, dust voids, vortices, etc). The latter are typical in astrophysical settings and in microgravity experiments. It appears that collective processes in a complex dusty plasma would have excellent future perspectives in the twenty first century, because they have not only potential applications in interplanetary space environments, or in understanding the physics of our universe, but also in advancing our scientific knowledge in multi-disciplinary areas of science.

The Lunar dusty plasmas -levitation and transport. NASA Astrophysics Data System (ADS) Atamaniuk, Barbara; Rothkaehl, Hanna

Lunar dust can exhibit unusual behavior -due to electron photoemission via solar-UV radiation the lunar surface represents a complex plasma -"dusty plasma". The dust grains and lunar surface are electrostatically charged by the Moon's interaction with the local plasma environ-ment and the photoemission of electrons due to solar UV and X-rays. This effect causes the like-charged surface and dust particles to repel each other, and creates a near-surface electric field. Lunar dust must be treated as a dusty plasma. Using analytic (kinetic (Vlasov) and magnetohydrodynamic theory) and numerical modeling we show physical processes related to levitation and transport dusty plasma on the Moon. These dust grains could affect the lunar environment for radio wave and plasma diagnostics and interfere with exploration activities. References: 1. Wilson T.L. (1992), in Analysis of Interplanetary Dust, M. Zolensky et al. AIP Conf.Proc. 310, 33-44 (AIP, NY), 2.Wilson T.L."LUNAR DUST AND DUSTY PLASMA PHYSICS".40th Lunar and Planetary Science Conference (2009), 3. GrÃ¼n E., et al.(1993),Nature 363, 144. 4. Morfill G. and GrÃ¼n E.(1979), Planet. Space Sci.. 27, 1269, 1283, 5. Manka R. and Michel F. (1971), Proc. 2nd Lun. Sci. Conf. 2, 1717 (MIT Press, Cambridge). 6. Manka R. et al.(1973), Lun. Sci.-III, 504. 7. Barbara Atamaniuk "Kinetic Description of Localized Plasma Structure in Dusty Plasmas". Czechoslovak Journal of Physics Vol.54 C 2004

Attenuation characteristics of electromagnetic waves in a weak collisional and fully ionized dusty plasma NASA Astrophysics Data System (ADS) Dan, Li; Guo, Li-Xin; Li, Jiang-Ting; Chen, Wei; Yan, Xu; Huang, Qing-Qing 2017-09-01

The expression of complex dielectric permittivity for non-magnetized fully ionized dusty plasma is obtained based on the kinetic equation in the Fokker-Planck-Landau collision model and the charging equation of the statistical theory. The influences of density, average size of dust grains, and balanced charging of the charge number of dust particles on the attenuation properties of electromagnetic waves in fully ionized dusty plasma are investigated by calculating the attenuation constant. In addition, the attenuation characteristics of weakly ionized and fully ionized dusty plasmas are compared. Results enriched the physical mechanisms of microwave attenuation for fully ionized dusty plasma and provide a theoretical basis for future studies.

Charged dust phenomena in the near-Earth space environment. PubMed Scales, W A; Mahmoudian, A 2016-10-01

Dusty (or complex) plasmas in the Earth's middle and upper atmosphere ultimately result in exotic phenomena that are currently forefront research issues in the space science community. This paper presents some of the basic criteria and fundamental physical processes associated with the creation, evolution and dynamics of dusty plasmas in the near-Earth space environment. Recent remote sensing techniques to probe naturally created dusty plasma regions are also discussed. These include ground-based experiments employing high-power radio wave interaction. Some characteristics of the dusty plasmas that are actively produced by space-borne aerosol release experiments are discussed. Basic models that may be used to investigate the characteristics of such dusty plasma regions are presented.

Dusty (complex) plasmas: recent developments, advances, and unsolved problems NASA Astrophysics Data System (ADS) Popel, Sergey

The area of dusty (complex) plasma research is a vibrant subfield of plasma physics that be-longs to frontier research in physical sciences. This area is intrinsically interdisciplinary and encompasses astrophysics, planetary science, atmospheric science, magnetic fusion energy sci-ence, and various applied technologies. The research in dusty plasma started after two major discoveries in very different areas: (1) the discovery by the Voyager 2 spacecraft in 1980 of the radial spokes in Saturn's B ring, and (2) the discovery of the early 80's growth of contaminating dust particles in plasma processing. Dusty plasmas are ubiquitous in the universe; examples are proto-planetary and solar nebulae, molecular clouds, supernovae explosions, interplanetary medium, circumsolar rings, and asteroids. Within the solar system, we have planetary rings (e.g., Saturn and Jupiter), Martian atmosphere, cometary tails and comae, dust clouds on the Moon, etc. Close to the Earth, there are noctilucent clouds and polar mesospheric summer echoes, which are clouds of tiny (charged) ice particles that are formed in the summer polar mesosphere at the altitudes of about 82-95 km. Dust and dusty plasmas are also found in the vicinity of artificial satellites and space stations. Dust also turns out to be common in labo-ratory plasmas, such as in the processing of semiconductors and in tokamaks. In processing plasmas, dust particles are actually grown in the discharge from the reactive gases used to form the plasmas. An example of the relevance of industrial dusty plasmas is the growth of silicon microcrystals for improved solar cells in the future. In fact, nanostructured polymorphous sili-con films provide solar cells with high and time stable efficiency. These nano-materials can also be used for the fabrication of ultra-large-scale integration circuits, display devices, single electron devices, light emitting diodes, laser diodes, and others. In microelectronic industries, dust has to be kept under control in the manufacture of microchips, otherwise charged dust particles (also known as killer particles) can destroy electronic circuits. In magnetic fusion research using tokamaks, one realizes that the absorption of tritium by dust fragments could cause a serious health hazard. The evaporation of dust particles could also lead to bremsstrahlung adversely affecting the energy gain of the tokamaks or other fusion devices. The specific features of dusty plasmas are a possibility of the formation of dust Coulomb lattices and the anomalous dissi-pation arising due to the interplay between plasmas and charged dust grains. These features determine new physics of dusty plasmas including, in particular, phase transitions and critical point phenomena, wave propagation, nonlinear effects and turbulence, dissipative and coherent structures, etc. The present review covers the main aspects of the area of dusty (complex) plasma research. The author acknowledges the financial support of the Division of Earth Sciences, Russian Academy of Sciences (the basic research program “Nanoscale particles in nature and technogenic products: conditions of existence, physical and chemical properties, and mech-anisms of formation”), of the Division of Physical Sciences, Russian Academy of Sciences (the basic research program “Plasma physics in the Solar system”), of the Dynasty Foundation, as well as of the Russian Foundation for Basic Research.

Plasma Physics Applied (New Book) NASA Astrophysics Data System (ADS) Grabbe, Crockett 2007-03-01

0.5cm Plasma physics applications are one of the most rapidly growing fields in engineering & applied science today. The last decade alone has seen the rapid emergence of new applications such as dusty plasmas in the semiconductor and microchip industries, and plasma TVs. In addition, this last decade saw the achievement of the 50-year Lawson breakeven condition for fusion. With new discoveries in space plasma physics and applications to spacecraft for worldwide communication and space weather, as well as new applications being discovered, this diversity is always expanding. The new book Plasma Physics Applied reviews developments in several of these areas. Chapter 1 reviews the content and its authors, and is followed by a more comprehensive review of plasma physics applications in general in Chapter 2. Plasma applications in combustion and environmental uses are presented in Chapter 3. Lightning effects in planetary magnetospheres and potential application are described in Chapter 4. The area of dusty plasmas in both industrial and space plasmas and their applications are reviewed in Chapter 5. The particular area of Coulomb clusters in dusty plasmas is presented in Chapter 6. The variety of approaches to plasma confinement in magnetic devices for fusion are laid out in Chapter 7. Finally, an overview of plasma accelerator developments and their applications are presented in Chapter 8.

Final Technical Report for Grant DE-FG02-04ER54795 DOE Office of Scientific and Technical Information (OSTI.GOV) Merlino, Robert L

This is the final technical report for DOE Grant #DE-FG02-04ER54795-Experimental Investigations of Fundamental Processes in Dusty Plasmas. A plasma is an ionized gas, and a dusty plasmas is a plasma that contains, in addition to electrons and ions, micron-sized dust particles. The dust particles acquire and electric charge in the plasma by collecting electrons and ions. The electrons move more rapidly than the ions, so the dust charge is negative. A 1 micron dust particle in a typical low temperature plasma has a charge corresponding to approximately 2000 electrons. Dusty plasmas are naturally found in astrophysical plasmas, planetary rings, technologicalmoreÂ Â» plasmas, and magnetic fusion plasmas. The goal of this project was to study in the laboratory, the basic physical processes that occur in dusty plasmas. This report provides a summary of the major scientific products and activities of this award.Â«Â less

On the generation of cnoidal waves in ion beam-dusty plasma containing superthermal electrons and ions NASA Astrophysics Data System (ADS) El-Bedwehy, N. A. 2016-07-01

The reductive perturbation technique is used for investigating an ion beam-dusty plasma system consisting of two opposite polarity dusty grains, and superthermal electrons and ions in addition to ion beam. A two-dimensional Kadomtsev-Petviashvili equation is derived. The solution of this equation, employing PainlevÃ© analysis, leads to cnoidal waves. The dependence of the structural features of these waves on the physical plasma parameters is investigated.

On the generation of cnoidal waves in ion beam-dusty plasma containing superthermal electrons and ions DOE Office of Scientific and Technical Information (OSTI.GOV) El-Bedwehy, N. A., E-mail: nab-elbedwehy@yahoo.com 2016-07-15

The reductive perturbation technique is used for investigating an ion beam-dusty plasma system consisting of two opposite polarity dusty grains, and superthermal electrons and ions in addition to ion beam. A two-dimensional Kadomtsevâ€“Petviashvili equation is derived. The solution of this equation, employing PainlevÃ© analysis, leads to cnoidal waves. The dependence of the structural features of these waves on the physical plasma parameters is investigated.

Dust-acoustic waves and stability in the permeating dusty plasma. II. Power-law distributions DOE Office of Scientific and Technical Information (OSTI.GOV) Gong Jingyu; Du Jiulin; Liu Zhipeng 2012-08-15

The dust-acoustic waves and the stability theory for the permeating dusty plasma with power-law distributions are studied by using nonextensive q-statistics. In two limiting physical cases, when the thermal velocity of the flowing dusty plasma is much larger than, and much smaller than the phase velocity of the waves, we derived the dust-acoustic wave frequency, the instability growth rate, and the instability critical flowing velocity. As compared with the formulae obtained in part I [Gong et al., Phys. Plasmas 19, 043704 (2012)], all formulae of the present cases and the resulting plasma characteristics are q-dependent, and the power-law distribution ofmoreÂ Â» each plasma component of the permeating dusty plasma has a different q-parameter and thus has a different nonextensive effect. Further, we make numerical analyses of an example that a cometary plasma tail is passing through the interplanetary space dusty plasma and we show that these power-law distributions have significant effects on the plasma characteristics of this kind of plasma environment.Â«Â less

Equation of state for two-dimensional dusty plasma liquids and its applications NASA Astrophysics Data System (ADS) Feng, Yan 2017-10-01

Laboratory dusty plasma consists of free electrons, free ions, and micro-sized dust particles with thousands of negative elementary charges. Due to their extremely low charge-to-mass ratio, these dust particles are strongly coupled, arranging themselves like atoms in liquids or solids. Due to the shielding effects of electrons and ions, dust particles interact with each other through the Yukawa potential, so that simulations of Yukawa liquids or solids are used to study properties of dusty plasmas. In the past two decades, the properties of liquid 2D dusty plasmas have been widely studied from experiments to theories and simulations. However, from our literature search, we have not found a quantitative and comprehensive study of properties of 2D liquid dusty plasmas over a wide range of plasma conditions. Here, from molecular-dynamics simulations of Yukawa liquids, we have obtained a concise equation of state (EOS) for the 2D liquid dusty plasmas from empirical fitting, which contains three quantities of the internal pressure, the coupling parameter, and the screening parameter. From this EOS, different thermodynamical processes can be directly derived, such as isotherms, isobars and isochores. Also, various physical properties of 2D liquid dusty plasmas, like the bulk modulus of elasticity, can be analytically derived, so that the sound speeds can be obtained. Finally, an analytical expression of the specific heat for 2D liquid dusty plasmas has been achieved. Work supported by the National Natural Science Foundation of China under Grant No. 11505124, the 1000 Youth Talents Plan, and the startup funds from Soochow University.

Lunar Dust and Dusty Plasma Physics NASA Technical Reports Server (NTRS) Wilson, Thomas L. 2009-01-01

In the plasma and radiation environment of space, small dust grains from the Moon s surface can become charged. This has the consequence that their motion is determined by electromagnetic as well as gravitational forces. The result is a plasma-like condition known as “dusty plasmas” with the consequence that lunar dust can migrate and be transported by magnetic, electric, and gravitational fields into places where heavier, neutral debris cannot. Dust on the Moon can exhibit unusual behavior, being accelerated into orbit by electrostatic surface potentials as blow-off dust, or being swept away by moving magnetic fields like the solar wind as pick-up dust. Hence, lunar dust must necessarily be treated as a dusty plasma subject to the physics of magnetohydrodynamics (MHD). A review of this subject has been given before [1], but a synopsis will be presented here to make it more readily available for lunar scientists.

A dusty plasma 1-ring to rule them all NASA Astrophysics Data System (ADS) Sheridan, T. E.; Gallagher, James C. 2010-04-01

One-dimensional and quasi-one-dimensional strongly-coupled dusty plasma rings have been created experimentally in the DONUT (Dusty ONU experimenT) apparatus. Longitudinal (acoustic) and transverse (optical) dispersion relations for the 1-ring were measured and found to be in very good agreement with the theory for an unbounded straight chain of particles interacting through a Yukawa (i.e., screened Coulomb or Debye-H”uckel) potential. These rings provide a new system in which to study one-dimensional and quasi-one-dimensional physics.

Lab- and space-based researchers discuss plasma experiments NASA Astrophysics Data System (ADS) Baker, D. N.; Yamada, M.

Plasma physics provides a common language and set of approaches that tie together all scientists who study the acceleration, transport, and loss processes of the plasma state. Some years ago, researchers from the laboratory and space research communities suggested a workshop to bring together the diverse researchers in the respective fields. A series of workshops on the â€œInterrelationship between Plasma Experiments in the Laboratory and Spaceâ€ (IPELS) was established, and the third meeting was held July 24-28, 1995, in the beautiful and historic town of Pitlochry in the Scottish Highlands.The conference reestablished the critical point that plasma physics is an important but surprisingly diversified research discipline. Meetings attendees discussed a number of new approaches to plasma research, including novel diagnostic techniques for use in space, such as active antennas and electric field sounding devices. Detailed discussions covered spacecraft-plasma environment interactions, including vehicle charging and neutral gas release; fundamental aspects of industrial application of dusty plasmas and waves in dusty plasmas; a very distinctive phase transition of coulomb crystals (from solid state to liquid state) in dusty plasmas; and terrella experiments to simulate and study chaotic transport in the ionosphere.

Dust trajectories and diagnostic applications beyond strongly coupled dusty plasmas NASA Astrophysics Data System (ADS) Wang, Zhehui; TicoÅŸ, CÇŽtÇŽlin M.; Wurden, Glen A. 2007-10-01

Plasma interaction with dust is of growing interest for a number of reasons. On the one hand, dusty plasma research has become one of the most vibrant branches of plasma science. On the other hand, substantially less is known about dust dynamics outside the laboratory strongly coupled dusty-plasma regime, which typically corresponds to 1015m-3 electron density with ions at room temperature. Dust dynamics is also important to magnetic fusion because of concerns about safety and potential dust contamination of the fusion core. Dust trajectories are measured under two plasma conditions, both of which have larger densities and hotter ions than in typical dusty plasmas. Plasma-flow drag force, dominating over other forces in flowing plasmas, can explain the dust motion. In addition, quantitative understanding of dust trajectories is the basis for diagnostic applications using dust. Observation of hypervelocity dust in laboratory enables dust as diagnostic tool (hypervelocity dust injection) in magnetic fusion. In colder plasmas (Ëœ10eV or less), dust with known physical and chemical properties can be used as microparticle tracers to measure both the magnitude and directions of flows in plasmas with good spatial resolution as the microparticle tracer velocimetry.

A hypothetical dusty plasma mechanism of Hessdalen lights NASA Astrophysics Data System (ADS) Paiva, G. S.; Taft, C. A. 2010-10-01

Hessdalen lights (HL) are unexplained light balls usually seen in the valley of Hessdalen, Norway. In this work, it is suggested that HL are formed by a cluster of macroscopic Coulomb crystals in a plasma produced by the ionization of air and dust by alpha particles during radon decay in the dusty atmosphere. Several physical properties (oscillation, geometric structure, and light spectrum) observed in HL phenomenon can be explained through the dust plasma model.

Dust-gas Interactions in Dusty X-ray Emitting Plasmas NASA Technical Reports Server (NTRS) Dwek, Eli 2006-01-01

Dusty shocked plasmas cool primarily by infrared emission from dust that is collisionally heated by the ambient hot gas. The infrared emission provides therefore an excellent diagnostic of the conditions (density and temperature) of the shocked gas. In this review I will discuss the physical processes in these plasmas, with a particular emphasis on recent infrared observations of the interaction between the blast wave of SN1987a and its equatorial ring.

3. CONCLUSION

We have studied the linear propagation of IA waves in an unmagnetized dusty plasma containing Boltzmann-distributed electrons and ions, mobile charge fluctuating negative dust, and charge fluctuating stationary negative dust. We have shown here how the nonlinear IA waves' basic features are modified by the charge fluctuating dust in dusty plasmas. The results, which have been obtained from this investigation, can be summarized as follows:

The dust charge fluctuation is a source of dissipation and is responsible for forming IA shock waves in the dusty plasma. The shock structures are associated with the negative potential (A<0) as well as the positive potential (A<0). It is shown that the height (normalized by) of the potential structures in the form of the shock waves is directly proportional to the shock speed , and it is also found that the thickness (normalized by) of these shock structures is inversely proportional to the shock speed .

The parametric regimes for the existence of positive as well as negative shock structures are shown in Fig.1. Figs. 2 and 3 show the positive and negative shock potential profiles of shock waves respectively.

It is to be mentioned here that the parameters we have chosen in our numerical analysis are very much relevant to the plasma in the mesosphere [27]. We stress that the results of the present investigation could be useful in understanding the properties of localized DA waves of dusty plasmas in the mesosphere.

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